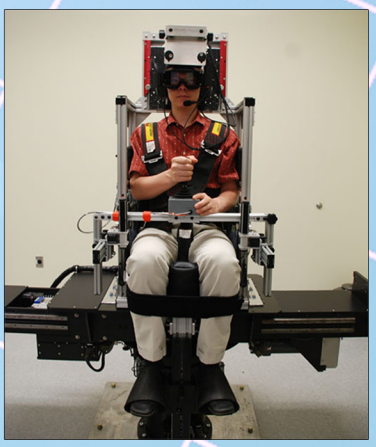
National Aeronautics and Space Administration

# John F. Kennedy Space Center's Core Technical Capabilities Catalog










*John F. Kennedy Space Center*

# Core Technical Capabilities

*2008*

# Core Technical Capabilities

## INTRODUCTION

Core Technical Capabilities (CTC) provide the foundation for Kennedy Space Center to excel as the Nation's leading spaceport through the development of advanced technologies, systems, and equipment. This technical base is composed of expert scientists, engineers, and technicians. Supported by state-of-the-art instruments and equipment in multidisciplinary laboratories, these teams conceive, develop, and perfect the innovative technologies that improve spacecraft processing, lower its cost, and further America's exploration mission. It is the innovative problem solving and rapid response of the Core Technical laboratories that enable KSC to overcome the technical challenges of spacecraft processing and launch operations. This document summarizes the capabilities of the Core Technical laboratories, key elements needed to serve the requirements of KSC-resident programs, as well as external customers.

## CONTENTS

# *Chemistry and Physics Laboratories*

# Applied Chemistry Laboratory

The Applied Chemistry Laboratory develops technology for toxic-vapor detection, chemical scrubbers for toxic wastes, *in situ* resource utilization processes, microencapsulation of materials for space applications, hypergolic-fuel dosimetry, hydrogen detection, self-healing wire insulation, minimally intrusive repair methods for electrical wiring, and environmental remediation.

Laboratory staff employ expert skills in polymer chemistry, analytical chemistry, physical chemistry, fluorescence, organic synthesis, electrochemistry, capacitance, transport phenomena, analytical-instrument development and testing, sensors, fabrication, and machining.

Other laboratory projects include the development of new polyimide-based powder coating systems, production of oxygen from carbon dioxide by electrolysis in ionic liquids, and development of new composite conductors. Work has also been performed on the production of a nontoxic, non-global-warming, non-ozone-depleting fire-extinguishing agent. The laboratory provides research and evaluation for environmental remediation, especially groundwater remediation technologies (permeable reactive barriers and emulsion-based cleanup technologies).


*Chemochromic tape shown on Shuttle fuel lines for detecting hydrogen leaks*

## Laboratory Assets & Specialized Equipment

- KIN-TEK vapor standards generators (dynamic range for hypergols: 10 ppb to 500 ppm)
- Dionex Ion Chromatography System (autosampler with electrochemistry detector)
- Tenney Versa Tenn II Environmental Test Chamber
- BAS 100B Potentiostat, BAS Galvanostat (LG50), and PWR3 Power Module
- Agilent 5973 Gas Chromatograph with Mass Spectrometer (GC/MS)
- Agilent 7970 GC with flame and thermal conductivity detectors with gas-sampling and column-switching valves
- Varian Triple Quadrupole GC/MS, electron ionization (EI) or positive/negative chemical ionization (CI)
- Shimadzu 8400S Fourier Transform Infrared (ATR, Diffuse Reflectance)
- Varian high-performance liquid chromatography (HPLC), ultraviolet (UV) detector, refractive index detector, gel permeation column
- Thermo Fisher Ion Trap Mass Spectrometer
- Jasco V-670 UV-Vis-NIR Spectrophotometer
- Konica Minolta ChromaMeter 400 (color analysis)
- Ocean Optics Fiber Optic Fluorometer
- Spex FluoroMax-3 Fluorometer
- Instrument Specialists Simultaneous Differential Scanning Calorimeter (DSC)/Thermogravimetric Analyzer (TGA)
- LECO TCH600 Nitrogen/Oxygen/Hydrogen Determination
- Instron 3344 Universal Testing Machine
- TA Instruments Q50 TGA
- TA Instruments Q200 DSC
- TA Instruments Q800 DMA
- Labconco FreeZone 4.5 Freeze Dryer System
- ATM Sonic Sifter
- Two PowerGen homogenizers
- Various high-speed mixers

*Oxygen production from lunar regolith*

## Recent Notable Achievements

- Developed a nitrogen oxide emission control for hypergols, which is being field-tested at a coal-fired power plant to control NOx and SOx (oxides of nitrogen and sulfur) emissions. Received one patent, filed four additional patent applications, and was awarded NASA Commercial Invention of the Year in 2000.
- Developed and tested a groundwater treatment technology for the removal of environmental contaminants from the groundwater around industrial areas, such as rocket launch pads, and cleanup of Superfund sites. The technology was named NASA's 2005 Commercial Invention of the Year and NASA's 2005 Government Invention of the Year.
- Developed self-healing wire insulation concepts and minimally intrusive manual repair methods for electrical wiring. Demonstrated in the laboratory the ability to detect a break in the electrical wiring insulation. Filed a provisional patent application.
- Conducted studies of halon replacement materials that resulted in a patent application and licensing interest.
- Fabricated, tested, and delivered a portable instrumentation system to monitor for leaks of hypergols during the fueling of spacecraft.
- Developed and tested a color indicator for the quick determination of hypergolic leaks within the Space Shuttle auxiliary power unit (APU) fuel transfer lines.
- Developed and field-tested a wipe that changes color based on the "cleanliness" of the wiped surface. Residual oxidizer turns the wipe red; residual fuel turns the wipe blue. This application is used in the external area around the Space Shuttle APU transfer lines.
- Developed and tested a color indicator for the quick determination of hydrogen leaks.
- Developed pattern recognition software for electronic-nose technology.
- Developed and tested a handheld PC application that allows for communication between electronic-nose instrumentation and both qualification and quantification of vapor samples containing hypergols, as well as organic components.
- Improved the sensitivity of the Makel sensor to detect 1 ppb hydrazine/monomethylhydrazine by changing the sensor body and varying the sensor temperature.
- Produced more than 25 technical publications and presentations, over 30 NASA New Technology Reports, 4 NASA Tech Briefs, 3 provisional patent applications, and 2 patent applications. Received 7 Space Act Awards, the NASA Commercial Invention of the Year for 2000 and 2005, and the NASA Government Invention of the Year for 2005 (which resulted from laboratory efforts since January 2000).

## Staff Credentials

- Chemical Engineers
- Chemists
- Engineering Aides
- Engineering Designers
- Physicists

## Laboratory Services

- Generation of hypergolic vapors from 10 ppb to 500 ppm
- Chemical problem solving
- Analytical services, including GC/MS, ion chromatography, ultraviolet-visible spectroscopy, Fourier transform infrared spectroscopy, fluorescence spectroscopy, and thermal analysis
- Electrochemistry: direct current/alternating current electrochemical experimentation and analysis
- Coulometric analysis of vapor samples
- Environmental test development and evaluation
- Instrumentation development

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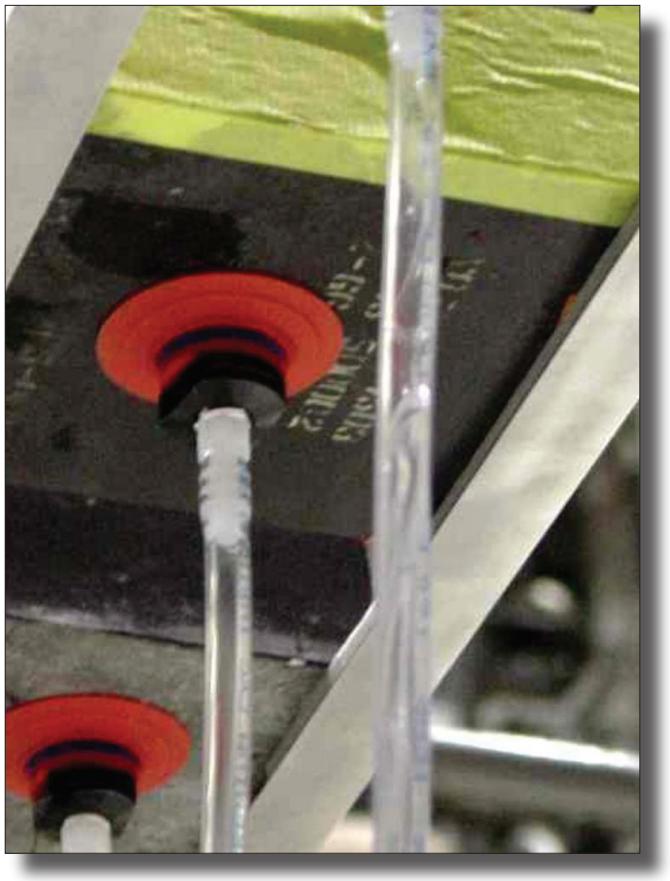
*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Applied Physics Laboratory

The Applied Physics Laboratory specializes in technology response with applied physics. The laboratory responds to problems from the Shuttle, Expendable Launch Vehicle, International Space Station/Payloads, Crew Exploration Vehicle, *In Situ* Resource Utilization, and future programs and works to solve them using concepts at technology readiness levels 3 and 4. Laboratory personnel take demonstrated concepts that can solve a problem and ultimately turn them into field-worthy hardware. Primary areas of expertise are electromagnetic radiation (mainly ultraviolet, optical, infrared, and millimeter), ultrasonics, sensor development, and mechanical system design. Work focuses on advanced sensors and systems for measurement and leak visualization and detection, nondestructive evaluation of flight hardware and ground support equipment, flight hardware positioning systems, and cryogenics. The Applied Physics Laboratory works closely with several contractor-operated laboratories that help make demonstrated concepts into operational hardware.

## Laboratory Services

- Applying physics technology and concepts, scientific investigation, engineering, electronics, mechanics, and modeling to solve specific flight hardware processing problems
- Developing technology for future programs
- Routing technical issues throughout the KSC engineering and scientific communities to seek solutions to spaceport problems
- Technically reviewing concepts in support of future and current spaceport upgrades



*Vacuum system for drying Space Shuttle tiles*

## Laboratory Assets & Specialized Equipment

- Class 4 Integra Laser
- Variety of lasers and light sources
- Optical table, mounting equipment, spectrometer, and a range of optics
- Wide assortment of electronics and mechanical components used to fabricate prototype systems to meet field problems
- Mathematica, Fortran, LabVIEW, and other software packages used to perform modeling and system analysis

## *Recent Notable Achievements*

- Conducted expert research in the development of capacitance-based technology, which has resulted in the delivery of sensing and measuring tools that have increased Shuttle safety and efficiency. One of our systems was recently implemented at the Stennis Space Flight Center to measure the height of cryogenic liquid in a high-pressure dewar.

- Patented and commercialized a remote scaling system that allows the Shuttle program to determine the size of objects as far away as 80 feet from a user.

- Delivered water removal and detection systems that are in use on the Shuttle to allow wet tiles to be found and then dried. We have continued this work in water detection and applied it to the Launch Services Program, where we are developing models and sensing approaches to monitor wet carbon composite.

- Currently working on techniques for locating, mapping, and measuring defects in glass. A scanning system is in development for use on the Orbiter windows, as well as two different tools to help inspectors measure defects.

- Designed and developed the following alignment and positioning tools for Shuttle processing, all of which improve safety and efficiency: an Orbiter wing tip alignment tool; a taper pin laser system to position the External Tank (ET) between the solid rocket motors; ET center-of-alignment system; laser/ultrasonic unit for aligning the gaseous oxygen vent hood over the ET; and an Orbiter jack and leveling system that accurately measures the height of the Orbiter.

- Designed and developed specialized tools and aids for the Shuttle program, including inspection tools for the Shuttle Reaction Control System nozzles; a set of illuminated Orbiter inspection mirrors; a device that projects light into the Shuttle window, causing defects to glow for easier and more accurate detection; a hail sensor for use at the launch pads; and a tool to help measure strain in the Orbiter sling.

- Performed work resulting in numerous NASA Tech Briefs, Space Act Awards, and patents.

## *Staff Credentials*

- Chemists
- Computer Scientists
- Electrical Engineers
- Mechanical Engineer
- Physicists

*Laboratory Operator & POC:*
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*Location:*
*Operations and Checkout Bldg. (M7-355)*

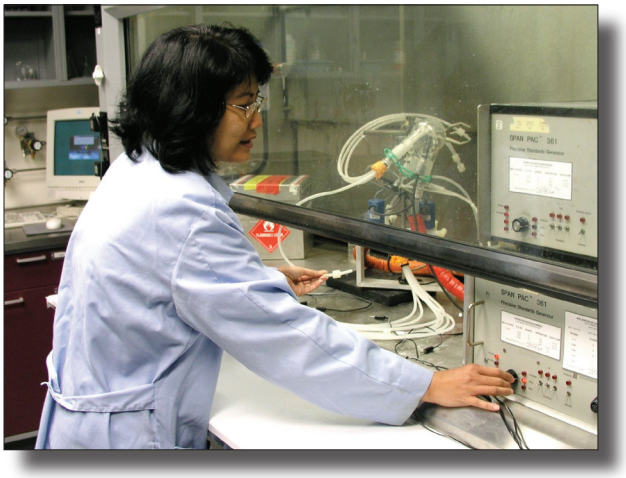
*Reaction Control System nozzle inspection tool*

# Chemical Analysis and Sampling Laboratory

The Chemical Analysis and Sampling Laboratory provides sampling and analytical support for NASA, the U.S. Air Force, and their contractors at KSC and Cape Canaveral Air Force Station. A variety of sample matrices, including high-pressure gases, hypergolic fluids and oxidizers, cryogens, assorted fluids, and environmental samples, are collected and analyzed to various NASA and military procurement and usage specifications and to Environmental Protection Agency (EPA) requirements. Housed in a state-of-the-art facility, the laboratory occupies approximately 30,000 square feet comprising several separate analytical areas, including gas, gas chromatography/mass spectrometry (GC/MS), metals, fuel, oxidizer, nonvolatile residue (NVR), particulate, and wet laboratories. Wide-ranging services are performed through the Toxic Vapor Detection (TVD) Laboratory, involving instrument calibrations and repairs and material compatibility and permeation testing. The capabilities for mercury spill support and in-place/onsite analysis of certain gases and fluids are also maintained. The laboratory complies with ISO 9000:2000, ISO 14001, AS 9100, and the National Aerospace and Defense Contractors Accreditation Program. In addition, the laboratory maintains State of Florida Department of Health/National Environmental Laboratory Accreditation Conference certification for sampling and analysis of environmental samples for EPA requirements and hazardous waste determinations.

## Laboratory Services

- Sampling and analysis: high-pressure gases and residual gas; hypergolic fuels and oxidizer; cryogenic substances; commodity fluids; environmental media
- Analytical procedure/methodology development
- TVD calibration/maintenance
- NVR/particulate determination
- Material compatibility/permeation studies
- Onsite sampling/analytical support
- Mercury spill support
- TVD acceptance and calibration protocols



## Staff Credentials

- Chemists
- Lab Technicians
- Sampling Technicians

## Laboratory Assets & Specialized Equipment

- GC/MS
- Gas chromatographs with ECD/FID/TCD/NPD
- Spectrophotometers (inductively coupled argon plasma, fourier transform infrared, ultraviolet/visible)
- Residual gas analyzer/mass spectrometer
- Ion chromatograph
- Analyzers (mercury, total hydrocarbon compound, total organic carbon, moisture [gas and Karl Fischer], $CO_2$)
- Stereo microscopes
- Tensiometers
- Dissolved-oxygen meters
- TVD Calibration Gas Generation System
- Distillation apparatus
- Electrical conductivity meter
- Flashpoint instruments
- Chromatographic Data Acquisition System
- Laboratory Information Management System
- Sampling equipment (various media)

## *Recent Notable Achievements*

- Provided analytical support to the Columbia Accident Investigation Board.
- Developed and implemented new analytical procedures/methodologies for Vetrel and HFE in support of component refurbishment transition away from freon-based precision-component cleaning.
- Developed and established a Fuel Dosimeter Badging Program in conjunction with the Naval Research Laboratory.
- Tested new prototype TVDs for the Hazardous Vapor Detection System (HVDS) 2000 Project.
- Developed analytical procedures for hydrogen peroxide in support of the X-37 Project and for gaseous impurities in ammonia in support of the International Space Station.
- Provided analytical support for the Crawler Refurbishment Project.
- Provided analytical support for the study of methods of detection of possible leaks in Orbiter fuel lines.
- Provided analytical support in the post-Columbia evaluation of Orbiter water system lines (NVR).
- Performed permeation testing for candidate self-contained atmospheric protective ensemble (SCAPE) suit materials.
- Developed calibration and acceptance procedures/protocol for new TVDs.
- Performed qualification testing of new candidates for replacement gross-point leak detectors to be installed at Shuttle launch pads.

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*Location:*
*Component Refurbishment and Chemical Analysis Facility (Bldg. K6-1696)*

# Chemical Test and Analysis Laboratory

The Chemical Test and Analysis Laboratory performs chemical identification of all states of matter (gas, liquid, and solid) in quantities down to micrometer-sized samples. These investigations are necessary to understand and solve chemical problems associated with the selection and application of materials for flight hardware, ground support equipment (GSE), and facility systems. The laboratory has collaborated with KSC and other NASA Centers in the following research and development efforts:

- Tile waterproofing
- Orbiter reinforced carbon-carbon leading-edge pinhole study
- Shuttle materials, such as alloys and soft goods
- Environmental effects of launch operations
- GSE materials, such as hypergolic scrubber fluids and launch structure components
- Contamination of the Orbiter ammonia boiler system
- Orbiter wiring insulation degradation
- Pre/postflight molecular contamination
- Environmental analysis
- Crawler Transporter shoes

The Chemical Test and Analysis Laboratory supports all KSC facilities, other NASA Centers, and other Government agencies in the analysis of samples for major and trace components; elemental, molecular, and surface composition; development of new methods of environmental testing; specialized analyses; and short-term chemical research and development.

## Laboratory Services

- Identify metal alloys, polymers, contaminants, lubricants, gases, and other materials of unknown composition
- Identify metals and metal alloys
- Identify organic, inorganic, and mixtures of contamination
- Characterize trace-level impurities
- Identify solid, liquid, or gaseous unknowns
- Sample gas and headspace by headspace and solid-phase microextraction
- Conduct surface analysis of thin films and trace contaminants
- Determine carbon, sulfur, hydrogen, nitrogen, and oxygen contents in metal alloys
- Characterize nonvolatile residue

*Scanning electron microscope with energy dispersive spectrometer and wavelength dispersive spectrometer*

## Recent Notable Achievements

- Solid Rocket Booster (SRB) Foam Debonding Failure Analysis: After failing a pull test, a section of SRB foam was removed from the lower stiffener ring and submitted for failure analysis. Conventional foam failure analysis involves chemically examining residues that may have caused the debonding. Because of the ambiguities of this type of analysis, a different approach was necessary. The foam was cross-sectioned, and polarized light microscopy and scanning electron microscopy were used to evaluate the microstructure of the failed bonding surface. The morphology of the fracture surface identified two modes of failure, an adhesive failure and a cohesive failure caused by severely deformed foam cells. The morphology indicated that the initial bond coat had not cured before other forces were applied, i.e., expansion of the second coat distorted the bonding cells.
- STS-121 Rainwater Intrusion Found in the Launch Complex 39B Payload Changeout Room: Gas chromatography/mass spectroscopy (GC/MS), ion chromatography, and inductively coupled plasma spectroscopy were used to analyze a clear, colorless liquid. It was determined that the liquid contamination was not rainwater; therefore, Pad B was cleared to launch STS-121.
- STEREO Propellant Loading Valve Residue: The STEREO spacecraft fuel bladder was filled with deionized water from a university's applied physics laboratory for spacecraft mechanical testing. When the water was drained from the spacecraft and nonvolatile residue (NVR) testing was performed, the results indicated a failed total solids specification test. The contamination was identified as an inorganic silicate material with minor amounts of carbonates.

- As a follow-on, purified water directly from the university's applied physics laboratory purification system was sampled for NVR testing, and it also failed the total solids specification test. Once again the contamination was identified as an inorganic silicate material with minor amounts of carbonates.
- E-85 Content Investigation at the On-Center Fuel Pump: During the servicing of U.S. General Services Administration (GSA) vehicles that are equipped to operate using E85 fuel (85% ethanol, 25% gasoline), the dealership believed that there was actually 95% ethanol in the fuel tank. Samples were taken from the on-center fuel pump and from a GSA vehicle at the dealership that contained the suspected fuel. They were analyzed with a GC/MS for ethanol content and compared with standards. It was determined that the concentrations of ethanol from both sources were nominally 85%. It is suspected that the dealership's monitoring system gave false high readings because the vehicle contained E85 with a small amount of unleaded gasoline; the vehicles are equipped to operate on E85 and normal unleaded gasoline.
- Natural-Gas Investigation in HQ Cafeteria: The Chemical Test and Analysis Laboratory was contacted after natural gas was detected outside the KSC Headquarters (HQ) cafeteria. The KSC Fire Department measured the natural-gas concentration outside the building and just inside the door to the kitchen. During their inspection, they discovered that all of the burner grates on the stoves were cool, thus indicating that the pilot lights were extinguished before the Fire Department's arrival. They also found two gas controls for the burners in the full ON position. The customer wanted to try to establish a timeframe in which the flames could have been extinguished. Three types of tests were performed to help narrow the time range in which the incident could have occurred: (1) natural-gas accumulation in the room, (2) extinguishing the flames by the fume hood, and (3) the time for the stove grates to become cool to the touch. The results indicated the minimum time that the flames could have been extinguished before the firefighters arrived at the scene. In addition, it was determined that there was no danger of flammable concentrations of natural gas accumulating in the kitchen.
- Silver as a Biocide for Potable Water Storage in the Crew Exploration Vehicle (CEV): Using scanning electron microscopy, the lab worked with Dynamac to evaluate three different types of metal coupons (Inconel 718, 21-6-9 stainless steel, and 316 stainless steel), which have been proposed to fabricate the potable water storage and distribution system for the new CEV. Ionic silver is being evaluated as an antimicrobial agent in the potable water systems. Dynamac scientists are interested in the interaction between ionic silver (added as silver fluoride to potable water) and the metal coupons, especially with the viability of five species of bacteria. The surfaces of approximately 40 metal coupons were imaged to show material degradation and the formation of a biofilm.

## *Laboratory Assets & Specialized Equipment*

- Fourier Transform Infrared Spectrometer
- Raman Spectrometer
- Scanning Electron Microscope with Energy-Dispersive Spectrometer and Wavelength-Dispersive Spectrometer
- Portable X-ray Fluorescence Spectrometer
- Inductively Coupled Plasma Spectrometer with Laser Ablation
- Gas Chromatograph – Mass Spectrometer
- Ion Chromatograph
- X-ray Diffractometer
- Direct Analysis in Real Time Mass Spectrometer
- Carbon-Sulfur-Hydrogen-Nitrogen in Metal Alloys Determinator
- LECO Hydrogen Determinator
- LECO Nitrogen-Oxygen Determinator
- CEM Digestion Microwave
- Optical Emission Metal Analyzer

## *Staff Credentials*

- Chemists
- Lab Technicians
- Materials Scientists
- Sampling Technicians
- Industrial Chemists

*Laboratory Operator & POC:*
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*Location: Operations and Checkout Bldg. (M7-355)*

# Electromagnetic Effects Laboratory

The Electromagnetic Effects Laboratory provides electromagnetic compatibility testing and troubleshooting, electromagnetic interference resolution, payload telemetry reradiating service, mobile and Center-wide fixed radio frequency (RF) surveillance, flight vehicle radar tracking beacon testing operations, and general support in the field of electromagnetic physics.

## Laboratory Services

- Electromagnetic compatibility (EMC) testing of ground support equipment (GSE), flight hardware, and facility systems to ensure compliance with MIL-STD-461, and similar standards:
  - Conducted emissions
  - Radiated emissions
  - Conducted susceptibility
  - Radiated susceptibility
  - Electrostatic discharge
  - Shielding effectiveness (MIL-STD-285/ IEEE 299)
  - Time domain transients
- Grounding, bonding, and shielding measurements
- General RF/microwave measurements up to 44 GHz
- RF amplifier characterization (gain, 1 dB and 3 dB compression points, bandwidth, spurious emissions, harmonics, intermodulation distortion)
- Vector signal analysis
- AC power quality analysis
- RF power density/field strength measurements
- RF environment site surveys from 14 kHz to 40 GHz
- Configuration of open-loop microwave links for payload-to-GSE communication
- Fabrication of antennas and measurement of parameters (voltage standing wave radio [VSWR], gain, beamwidth, bandwidth, front-to-back ratio)
- Antenna test range operations
- Electromagnetic interference investigation and direction finding
- Radar transponder beacon testing for all Eastern Range launch vehicles
- Monitoring and recording Flight Termination System signal activity during flight vehicle testing and launch operations for Shuttle, Constellation, Expendable Launch Vehicles (ELV), Evolved Expendable Launch Vehicles (EELV), and commercial launch services
- Launch vehicle radar beacon transponder parameter measurements
- Interference analysis and impact assessments for new emitters operating on KSC and the Eastern Range
- Technical support to the 45th Space Wing Frequency Management Office and Eastern Range
- Other electromagnetics studies and analyses

## Laboratory Assets & Specialized Equipment

- Two shielded enclosures and RF test apparatus necessary to perform compliance testing.
- Antenna test range west of Electromagnetics Effects Laboratory (EML).
- Assortment of antennas/sensors and general AC power and RF measurement instruments.
- Three specially equipped vans that provide mobile platforms for performing tests at remote locations.
- Two vans equipped to perform radar tracking beacon transponder checkout and RF interference (RFI) direction finding.
- Operations control room to support all launches at KSC or CCAFS.
- Radio Alert Sensor System (RASS) to provide warning and general geographical location of unauthorized local sources on the flight termination frequency.
- Surveillance antennas located on EML for launch and RFI support.
- Automated RF monitoring system that continuously monitors and records the RF environment, 24/7, from 100 MHz to 18/40 GHz at the following sites: EML, Operations and Checkout Building, Hangar AO, Vehicle Processing Facility, and Pads 39-A, 39-B, and 17-A. This is currently expanding to Pad 41. Adding signal geolocation capability to instantaneously locate emitter point of origin or line of bearing.

## Staff Credentials

- Professional Engineer (PE)
- NARTE Certified Engineer
- Electrical Engineers

## Notable Recent Achievements

- The EML traveled to Antigua to support the Eastern Range Tracking Station and the Antiguan Government in isolating RFI emitted from various sources located throughout the island.

- The EML provided support to sensor checkout efforts at Launch Complex 39 and triggered-lightning test support at the University of Florida's International Center for Lightning Research and Testing, Camp Blanding, Florida, for NASA's Ground Lightning Monitoring System's project. EME provided lightning strike simulation signals with a Helmholtz coil developed in-house. This support was provided in preparation for STS-125 – Hubble Space Telescope (HST).

- The EML identified and resolved a critical RF emission on 5625 MHz, which was interfering with the Patrick Air Force Base Weather Radar and identified as a potential constraint to CoFR by the NASA Weather Office.

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*Location:*
*Electromagnetics Laboratory (Bldg. M6-336)*

# Electrostatics and Surface Physics Laboratory

The Electrostatics and Surface Physics Laboratory is dedicated to investigating electrostatics and surface physics problems with applications to spaceflight and planetary exploration. The laboratory has routinely performed electrostatic testing of thin films and clothing materials since the 1960s, leading to the compilation of a comprehensive database on the electrostatic properties of materials. This laboratory can supply electrostatics information on thousands of thin films immediately and data on new materials in a very short time. Research is aggressive and accurate, involving worldwide collaborators in various disciplines. Laboratory personnel are frequently invited to participate in international conferences and have published and presented scores of technical papers. The Electrostatics and Surface Physics Laboratory is currently carrying out electrostatic analyses and materials characterization to assist in the detection, mitigation, and prevention of electrostatic charge generation on spaceflight hardware and Space Shuttle ground support equipment (GSE). The lab is also involved in dust mitigation efforts for lunar and Martian exploration and methods for planetary protection.

## Laboratory Services

The following electrostatic tests, measurements, and analyses are conducted in high and low temperatures, pressures, and humidities and at various atmospheric conditions:

- Surface resistance
- Charge decay and charge measurements
- Triboelectric charging measurements
- Volume resistivity
- Adhesion coefficient determination
- Electric field measurements
- Surface charge distribution
- Surface analysis techniques
- Embedded electrostatic sensor technology
- Plasma treatment of surfaces
- Hydrophobicity measurements
- Electrical conductivity and grounding determination

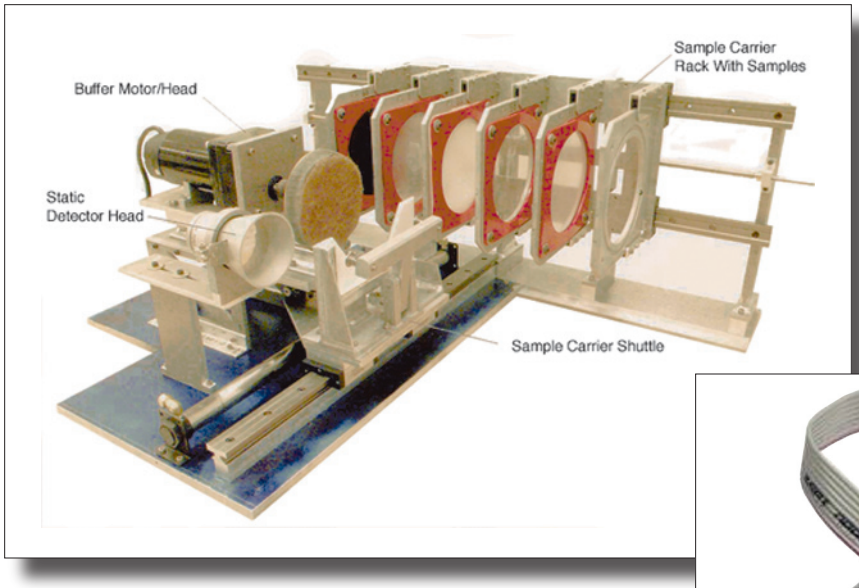
## Laboratory Assets & Specialized Equipment

- Various vacuum systems (3 bell jars; 2 of those 3 are stainless-steel ultrahigh vacuum-[UHV]-capable)
- Three environment chambers with state-of-the-art electrostatic measuring equipment (static monitors, charge decay, coulomb meters)
- X-ray photoelectron spectroscope (XPS)
- State-of-the-art electrostatics testing equipment
- Sputter coater
- Atmospheric plasma glow discharge sources
- Ultraviolet source and monochromator
- Optical emission spectrometer
- Contact angle measurements
- Sample preparation facilities
- Lunar and Mars dust simulants and 200 g Apollo 14, 16, and 17 lunar regolith
- Two portable fume hoods
- Two chemical fume hoods

*Lunar environmental chamber*

## Staff Credentials

- Physicists
- Scientists
- Engineers



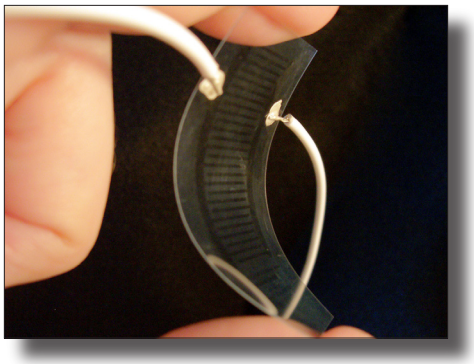

*Electrostatic discharge robot*

## *Recent Notable Achievements*

- Development of electrodynamic dust shields for dust mitigation
- State-of-the-art characterization of Apollo 14, 16, and 17 lunar regolith
- Electrostatic beneficiation of lunar regolith for *in situ* resource utilization
- Prevention of electrostatic discharge on replacement circuit boards for the Hubble Space Telescope repair mission
- Spark incendivity testing of Space Shuttle and International Space Station thermal insulation blankets
- Electrostatic precipitation for removal of contaminants in high-pressure gaseous-nitrogen lines
- Investigation of glow discharge in dust devils on Mars
- Development of electrostatically dissipative films using indium tin oxide and carbon nanotubes
- Electrostatics evaluation and design recommendation of the Hubble Space Telescope Imaging Spectrograph hardware


*Advanced multisensor electrometer*

*XPS Lab*



*Flexible transparent screen*

*Laboratory Lead & POC:*
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*Location:*
*Space Life Science Laboratory (Bldg. M6-1025)*

# Granular Materials and Regolith Operations Laboratory

The Granular Materials and Regolith Operations (GMRO) Laboratory has unique equipment and numerical modeling capabilities to solve powder and granular material technology problems for Shuttle, Crew Exploration Vehicle, and other missions. Many powders and granular materials are used in spacecraft processing, presenting a range of technology challenges. The lab has measured the mechanics of insulation powders for cryogenic dewars and developed new experimental techniques. The lab is developing sensors to detect and measure the motion of suspended particulates, such as in KSC clean rooms or in rocket exhaust plumes, and is continually developing new granular modeling techniques.

## Staff Credentials

- Applications Scientist
- Computer Scientist
- Mechanical Engineers
- Physicists

## Laboratory Assets & Specialized Equipment

- A complete complement of soil mechanical testers (proctor compactor, limit devices, vibration table with relative density set, triaxial shear tester, direct shear tester, consolidation tester, permeation cells)
- Regolith bed with 1 ton of Martian soil simulant and 2 tons of lunar soil simulant
- Fine-particle analyzer
- Rocket plume testers, penetrometers, small wind tunnel, coring devices, handheld testers, ultrasonic bath, drying oven, wet/dry sieve, dehumidifier, microscope, triaxial tester, hydrometer test set, cameras, high-speed camera, videographic analyzer, dust hood, sandblast hood, etc.
- High-end computer workstation with physics simulation software (PFC2D, PFC3D)

*Laboratory assets and equipment*

*Rocket cratering tests*

*GMSSL wind tunnel*

## *Recent Notable Achievements*

- Powder/granular mechanics theory developed in the lab has been published in leading science journals, was granted a Space Act Award, and has attracted international attention.

- The GMRO Lab at KSC has the *only* NASA expertise in this field.

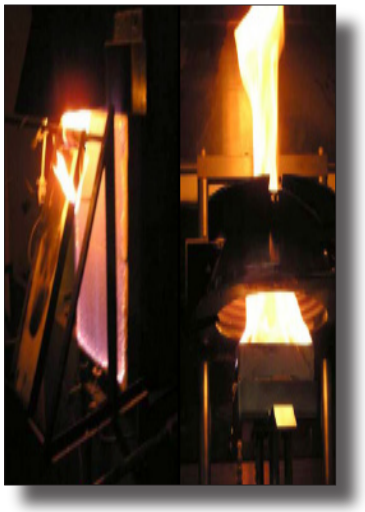
- The GMRO Lab was selected to lead the analysis of lunar plume effects for the Lunar Lander project. The discovery of a new flow regime in rocket exhaust cratering has been approved for publication in the *Journal of Aerospace Engineering*.

*Laboratory Operator & POC:*
*NASA – Dr. Philip T. Metzger, Mail Stop: KT-D-3, KSC, FL 32899*
*Philip.T.Metzger@nasa.gov, (321) 867-6052*

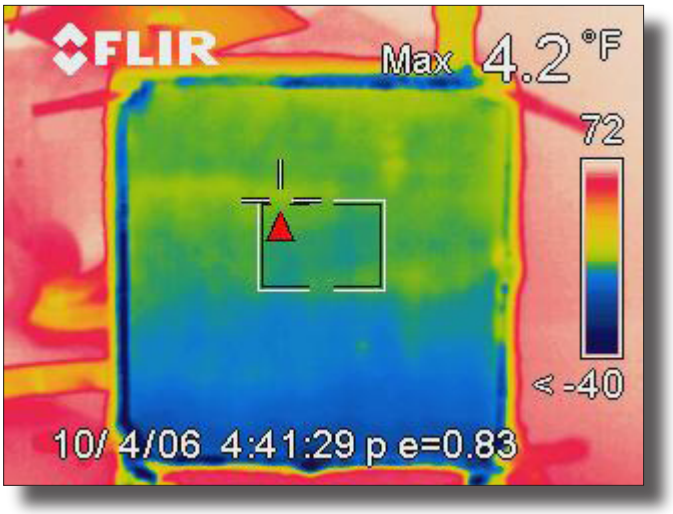
*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Polymer Science and Technology Laboratory

The Polymer Science and Technology (PSAT) Laboratory provides real-time problem solving and polymer materials development, testing, and support to multiple NASA and KSC programs. The PSAT team has a diverse background and expertise in foam and insulation systems, low-temperature composites, carbon nanotube technology, conducting-polymer systems, fire and polymers, and coating systems (including icephobic coatings, chemical sensor technology and polymer processing techniques), along with polymer and materials degradation mechanisms. With its trained personnel and diverse expertise, the PSAT team has supported several NASA and KSC initiatives, such as Shuttle, External Tank (ET), and the Launch Services Program on foam concerns, and the NASA Engineering Safety Center (NESC) efforts to use spray-on foam insulation (SOFI) to eliminate ice on the ET bracket and bellows for the Space Shuttle's return-to-flight. The team also collaborates with other laboratories within KSC and NASA, such as KSC's Cryogenics Laboratory, Applied Chemistry Laboratory, Electrostatics and Surface Physics Laboratory, Applied Physics Laboratory, and Corrosion Test Laboratory, as well as the Structures and Materials Branch at Langley Research Center.



*Fire testing*




*Infrared image of icephobic coating testing*

## Laboratory Services

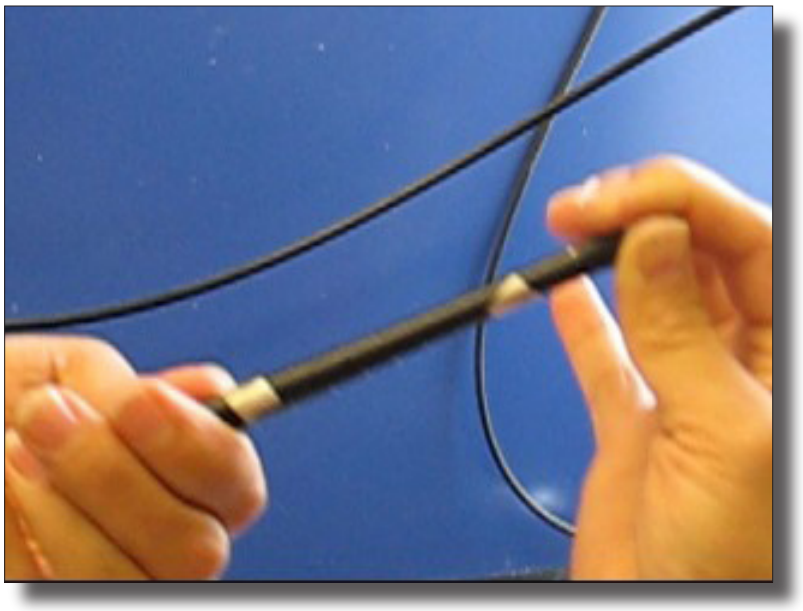
- Polymer and materials science expertise and consultation
- Characterization of polymer systems, including mechanical and thermal analysis
- Polymer synthesis and design, including conductive systems
- Insulation systems development and testing
- Polymer materials for low-temperature applications
- Fire properties of polymers
- Coating development
- High-performance material development

## Laboratory Assets & Specialized Equipment

- Cone calorimeter
- Instron
- 4-point probe
- Brabender Twin-Screw Extruder (includes a melt mixer with a plasticorder)
- 50-ton injection molder
- Thermogravimetric analyzer
- Differential scanning calorimeter
- Solution fiber spinner

## *Recent Notable Achievements*

- One patent on fire-retardant additive technology, four patents pending (low-temperature thermoplastic composites, low-temperature foam composites, hydrogen-sensing composite, and icephobic coating polymer system).
- Aerogel/polymer composite technology selected as one of the World's Best Technologies at the WBT Showcase Conference.
- PSAT-led Exploration Technology Development Program project given high marks from a National Research Council review.
- Significant contributor to multi-NESC and Shuttle activities in foam and materials challenges in cryogenic applications.
- Hydrogen-sensing technology used on the launch pad for the last two launches in 2007.



*Conductive detection systems design*

## *Staff Credentials*

- Polymer Chemists

*Laboratory Operator & POC:*
*NASA – Dr. Martha K. Williams, Mail Stop: KT-E-3, KSC, FL 32899*
*Martha.K.Williams@nasa.gov, (321) 867-4554*

*Locations:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*
*Operations and Checkout Bldg. (M7-355)*
*"Cone Shack" (Bldg. M6-1509)*

# *Electrical and Electronic Laboratories*

# Advanced Electronics and Technology Development Laboratory

The Advanced Electronics and Technology Development (AETD) Laboratory designs and develops instrumentation systems used for a broad spectrum of applications. These systems range from flight sensors to shop aids and include many systems used as ground support equipment (GSE). The collective staff expertise encompasses lightning research; analog, digital, and mixed-signal design; digital signal processing (DSP); advanced imaging; and mathematical modeling. The AETD Laboratory turns ideas into realities, even on short notice, developing electronic systems from conception through prototyping and often culminating in small-scale production. The emphasis on applied research has produced numerous patents covering a wide range of technical fields. The standards and dedication of the lab's personnel consistently result in meeting delivery schedules, fast responses to customer requests, and on-target costs.

## Laboratory Services

- Data acquisition systems design
- DSP algorithm and methodology development
- Lightning and electromagnetic measurement, data acquisition, analysis, and research
- Mathematical modeling and computer simulation
- Design of analog, digital, and mixed-signal electronic circuitry
- Electronics assembly (through-hole and fine-pitch surface-mount)
- Printed circuit board design, assembly, and testing
- Schematic capture
- Surface-mount and through-hole circuit board assembly
- Special instrumentation development


*ECO Sensor troubleshooting*

## Recent Notable Achievements

- Investigated the engine cutoff (ECO) sensor problems that occurred before the STS-122 launch. Troubleshooting with a time-domain reflectometer (TDR) revealed that the source of the problem was an external feed-through connector and not the sensor.
- Developed a Monte Carlo Statistical Tool to design and evaluate the lightning protection system (LPS) of complex structures. This program was used to design the new LPS of Launch Complex 39B and is being used for the design of the LPS of the Emergency Egress System.
- Developed smart network elements (SNEs) to provide reliable signal conditioning to raw sensors, complex data processing, and communication capabilities using the IEEE 1451 family of standards.
- Developed technology to perform laser repair of the Reaction Control System (RCS) nozzles, which will save the Shuttle program millions of dollars by extending the life of RCS nozzles that would have been removed from service.
- Developed an advanced cable tester that locates any breaks in the cables. This technology is patented and commercially available through Eclypse International, Inc. Additional research is in progress to develop a test instrument that will locate damage in cables that are not yet broken.
- Developed the Signal Conditioning Amplifier Recorder (SCAmpR), a highly reliable, remotely commanded, self-calibrating data acquisition system that records data at the signal conditioner while transmitting system health status and data using Ethernet technology. SCAmpR is patent-pending and has been licensed by Pacific Instruments, Inc.
- Developed the Sonic Lightning Locator (SOLLO) System. SOLLO is used to pinpoint the location of lightning strikes to within several meters. This system is very helpful in discovering damage caused by lightning. Two patents are held for this technology.
- Developed a self-healing Advanced Data Acquisition System for use in applications requiring extremely high reliability. This technology is patented.
- Developed a very sensitive Tile Moisture Sensor for detecting water intrusion into the Space Shuttle Thermal Protection System (TPS) tiles. Accurate moisture detection increases the cost efficiency of the drying procedure and improves Shuttle processing overall.
- Currently developing a lightning instrumentation system that will continuously monitor, record, and assess any lightning experienced by the vehicle, catenary wire system, or critical GSE near the launch pad or Mobile Launcher.
- Currently developing a ControlNet interface that will allow the SNEs to interface with programmable logic controllers.
- Currently developing a Portable Handheld Optical Window Inspection Device (PHOWID) to measure the 3D profile of defects on the surface of spacecraft windows. The system has a scanning resolution of 8 µm and depth-measuring capability to a resolution of 2 µm.
- Currently developing an Integrated Window Inspection Device (IWID) for reliably locating defects within 1.27 mm on the surface of spacecraft windows using a stress field camera. The system is capable of distinguishing among real defects, dust, shadows, and surface contamination.
- Currently developing a weather instrumentation system to continuously monitor, record, and assess environmental conditions at the launch pad, such as wind speed, wind direction, relative humidity, barometric pressure, temperature, and rain.
- Currently developing algorithms for processing acoustic emissions data that can detect damage to the Shuttle TPS during flight as the damage occurs. This technology can also be applied to other spacecrafts.
- Designed and developed the Universal Signal Conditioning Amplifier, which is the backbone of the Ground Measurements System (GMS), a high-speed data acquisition system used by Shuttle Operations to record processing- and launch-related data, including the 96 holddown post strain gauge measurements. GMS was implemented as a dual-use technology transfer agreement with L3 Communications, Inc. Two patents are held for this technology.

## Laboratory Assets & Specialized Equipment

- Printed circuit board milling machine
- Schematic capture and printed circuit board design workstations
- Surface-mount assembly stations
- Transient recorders for measuring lightning effects
- Fast-digitizing data acquisition recorders
- High-speed digital oscilloscopes
- High-speed, wideband serial data analyzer
- Programmable pulse generator and surge generator
- Time-domain reflectometer

## Staff Credentials

- Electrical Engineers
- Supporting Engineers
- Craftsmen
- Technicians

*Laboratory Operator & POCs:*
*NASA – Erik C. Denson, Mail Stop: NE-E7, KSC, FL 32899*
*Erik.C.Denson@nasa.gov, (321) 867-6537*

*NASA – Zachary Cline, Mail Stop: NE-E8, KSC, FL 32899*
*Zachary.K.Cline@nasa.gov, (321) 861-3723*

*Contractor – Dr. Carlos T. Mata, Mail Stop: ASRC-25, KSC, FL 32899*
*Carlos.T.Mata@nasa.gov, (321) 867-6964*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# Advanced Range and Systems Health Laboratory

The Advanced Range and Systems Health Laboratory is composed of Range Technologies Development, Advanced Communications, Ground Systems Health and Diagnostics, and Intelligent Devices. The laboratory designs, develops, and implements electronic systems for a broad spectrum of applications. The laboratory develops technologies related to range operations, communication systems, ground and vehicle processes and systems health management, and specialized instrumentation systems.

In the range technologies discipline, the laboratory develops and implements technologies that support safe and efficient range operations, such as Space-Based Range (SBR) and the Autonomous Flight Safety System (AFSS). It is also involved in tracking, surveillance, and telemetry. The laboratory presently supports calibration and certification of the Space Shuttle approach and landing aids using Global Positioning System (GPS) technology as a benchmark.

In the communication discipline, the laboratory evaluates and tests emerging communication technologies to address next-generation range and spaceport needs. It also works with electromagnetic wave propagation, free-space optics communication, millimeter wave communication, electromagnetic interference control and photonic band gap and ultra-wide band technologies.

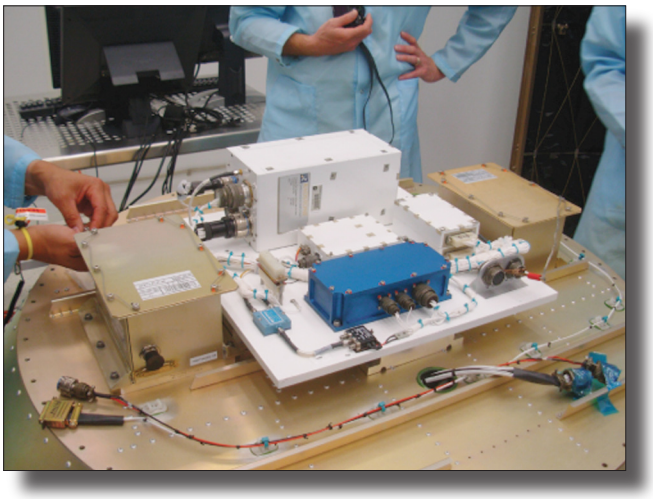
In the ground and vehicle health management discipline, the laboratory designs architecture, and develops and implements hardware and software systems and software algorithms in support of fault detection, isolation, and recovery (FDIR) operations.

The Advanced Range and Systems Health Laboratory also designs and develops intelligent devices (sensors and actuators with embedded intelligence for FDIR), as well as develops plug-and-play capabilities for the intelligent devices. These devices are designed to continuously assess their operation for failure or degradation.

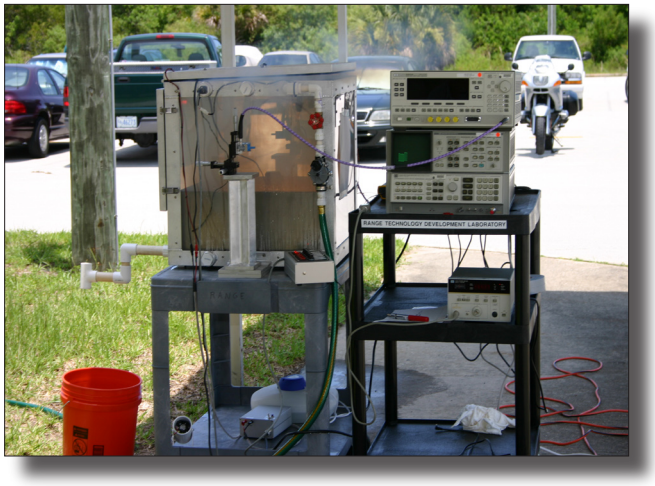
The laboratory has complete custom electronics design, development, prototyping, and test capabilities, as well as extensive software development and modeling capabilities.

## Recent Notable Achievements

- Innovative Partnership Program Ground Operations Health Management project: Successful demonstration of ground health management algorithms and intelligent sensors during the liquid oxygen cryogenic pump testing at Complex 20.
- Successful flight demonstration of radio frequency (RF) Health Node and SensorNet project systems during the launch and recovery of the Sub-TEC II sounding rocket launched from Wallops Flight Facility.
- Successful demonstrations of the AFSS and the GPS Metric Tracking System.



*AFSS payload processing for SpaceX Falcon 1 launch vehicle*



*Millimeter wave launch complex attenuation test chamber*

*Free-space optical testing*


*Free-space optical laser communication system testing at the Shuttle Landing Facility runway*

## Laboratories Services

- Develop technologies in support of SBR.
- Develop and test next-generation range instrumentation using GPS satellite simulators and tracking and modeling software
- Develop technologies in support of AFSS
- Develop and test next-generation lightning detection and ranging systems
- Develop, test, and install autonomous GPS-based landing systems
- Develop and demonstrate communication systems for range applications
- Develop Iridium satellite and Tracking and Data Relay Satellite (TDRS) communication links
- Field-test laser communications and laser target designator systems
- Apply GPS navigational signals to the calibration of landing aid systems and navigation
- Develop advanced RF and range communication systems
- Test and analyze tracking and visualization systems
- Evaluate and test early-stage communication exemplars for future spaceport, range, and launch vehicle use
- Develop FDIR algorithms using TEAMS, SHINE, IMS, and MatLab tools
- Develop digital signal processing (DSP) algorithms and methodology
- Develop mathematical models and computer simulation
- Design analog, digital, and mixed-signal electronic circuitry
- Develop special instrumentation

## Laboratory Assets & Specialized Equipment

- 14-satellite GPS simulator
- Plasma generation chamber-to-millimeter wave communication testing
- Satellite Development Kit (SDK) satellite location simulation software
- Real-time operating systems software development tools (VxWorks)
- Embedded system software development tools (MatLab, C++, Xilink, etc.)
- Optical test equipment and optical testbed
- FDIR development tools
- Schematic capture and printed circuit board design workstations
- GPS antennas (access to the building roof)
- Laser communication test set (access to building roof)

## Staff Credentials

- Electrical Engineers
- Electrical Technicians
- Machinist/Tool & Die
- Physicist
- Software Engineers

*Laboratory Operator & POCs*
*NASA - José Perotti, Mail Stop: KT-C, KSC, FL, 32899*
*Jose.M.Perotti@nasa.gov, (321) 867-6746*

*Contractor – Jay Amburgey, Mail Stop: ASRC-48*
*Ottis.J.Amburgey@nasa.gov, (321) 867-3809*

*Location: Engineering Development Laboratory (Bldg. M7-409)*

# Controls Laboratory

The Controls Laboratory develops, designs, prototypes, tests, and validates automated programmable logic control (PLC) systems for the Constellation ground support equipment (GSE). It provides PLC software and Supervisory Control and Data Acquisition (SCADA) applications for system monitoring and control. In particular, the Controls Laboratory has expertise and infrastructure for developing and testing PLC-based systems.

## Laboratory Services

- Provide the specialized skills required to design, develop, prototype, test, and validate automation control and monitoring systems and electrical/electronic control systems
- Design and develop associated embedded software specifically for support equipment
- C, C++, Ladder Logic, Function Block Diagram, Sequential Function Chart, SCADA
- Circuit Design

## Staff Credentials

- Computer Engineers
- Electrical Engineers
- Technicians

## Recent Notable Achievements

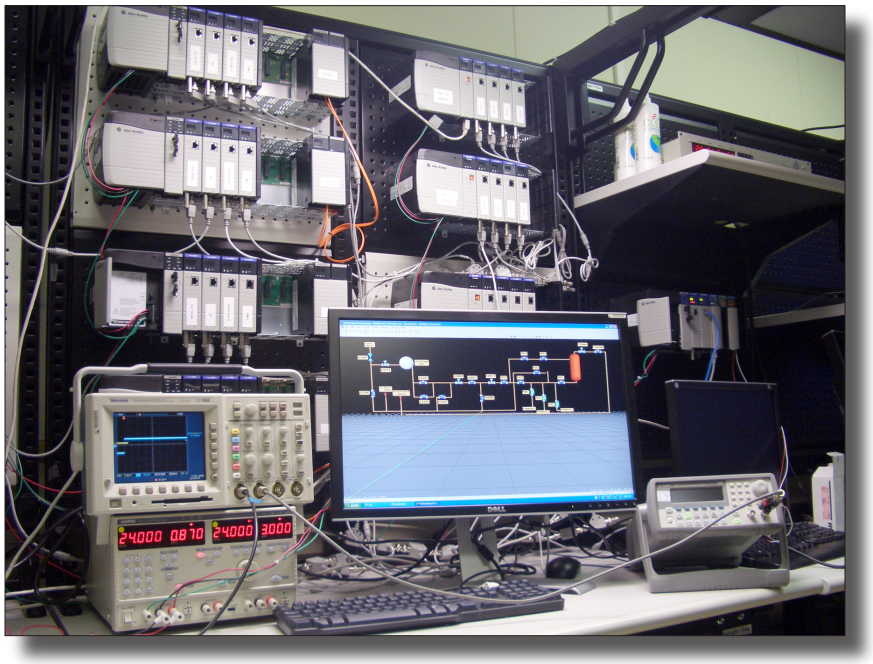
- Developed program, configured hardware, and established interfaces for proof of concept for control system architectures (including the GSE controls and Launch Control System [LCS] interface).
- Performed studies on topics such as communication using Ethernet/Internet Protocol and time stamping at the PLC level. The studies included hardware and software impacts on the interfaces between the LCS gateway computer and the Kennedy Ground Control System PLCs.

## Laboratory Assets & Specialized Equipment

- Software tools – LabVIEW, GE iFIX, Historian, RS Networks, Rockwell RSLogix, RSView
- Hardware development testbed utilizing Allen-Bradley PLCs

*Laboratory Operator & POC:*
*NASA – Tushar Patel, Mail Stop: NE-E8, KSC, FL 32899*
*Tushar.B.Patel@nasa.gov, (321) 867-6679*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*



The Electronic Development and Test Laboratory (ED&T) provides development, test, and troubleshooting capability for digital and analog electrical and electronic systems, including access to a wide range of state-of-the-art test equipment. The lab provides computer-aided design (CAD) software, including AutoCAD, AutoCAD Electrical, LabVIEW, and Pro/ENGINEER, as well as wide-format color and black and white (B&W) printing and scanning capability. These capabilities are used across multiple CTC labs.

## Recent Notable Achievements

- Supported Ares I-X development with ground- and flight-side hardware simulators.
- Supported flight demonstrations of the Integrated Vehicle Health Management (IVHM) System on STS-95 (John Glenn's return to space aboard Discovery) and STS-98 (Atlantis).
- Tested multiple instrumentation technology developments in a flight environment, leading to flight and ground implementations of the Micro Wireless Instrumentation System, the RF Health Node, Vacuum Jacket Pressure instrumentation, the Space-Based Telemetry and Range Safety Command and Data Handler Flight Processor, and the Autonomous Flight Safety System.

## Laboratory Services

- Provide lab area for development activities with access to test equipment and fabrication/rework capability
- Provide computers, printers, support software, and network connections to CAD/CAE servers
- Provide an area that supports collaboration among the design engineers
- Develop, test, and troubleshoot custom or commercial off-the-shelf (COTS) systems or subsystems

## Laboratory Assets & Specialized Equipment

- Oscilloscopes, power supplies, function generators, logic analyzers, thermal imager
- Wide range of software that includes AutoCAD, AutoCAD Electrical, Altium Designer, LabVIEW, and Pro/ENGINEER. Future access to Matlab planned.
- Wide-format printers – color/photo (42") and B&W (36")

*Laboratory Operator & POC:*
*NASA – Michael Kromann, Mail Stop: NE-E7, KSC, FL 32899*
*Michael.J.Kromann@nasa.gov, (321) 867-6690*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# Electrical/Electronics Failure Analysis Laboratory

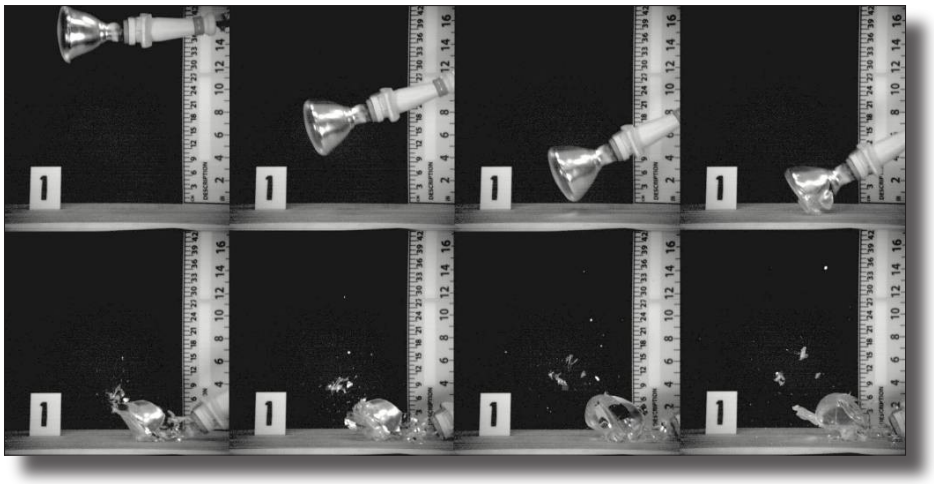
The Electrical/Electronics Failure Analysis Laboratory performs independent, unbiased failure analysis investigations to determine the root cause of ground support equipment (GSE) and flight hardware electrical and component failures. This analysis service involves both nondestructive parametric evaluations (NPE) and destructive physical analysis (DPA). To support its investigations, the laboratory maintains a real-time radiography system, digital photography and microscopy documentation capability, and infrared (IR) and standard and high-speed videography to document both field conditions and laboratory assessments of the failed components.

## Laboratory Services

- Failure analysis of electrical/electronic components, power components, cable assemblies, and subsystems (DPA, NPE, and real-time radiography and thermography)
- Low-magnification digital microscopy with macro/microphotography
- Advanced digital photodocumentation and videography
- Analog, digital, and mixed-signal component testing
- High-voltage facility power and high-frequency electrical and DC power system testing
- Low-voltage, nonintrusive simulation testing to field parameters
- Field analysis and data acquisition instrumentation/techniques

## Laboratory Assets & Specialized Equipment

- Variable voltage and frequency AC power system
- Sorenson DC High-Amperage Power System
- IRT 1200 Real-Time Radiographic Inspection System
- Wentworth Labs Integrated Circuit Probing Station
- Digital photography acquisition system with digital archive
- FLIR Infrared Thermography Inspection System
- Analog and digital videography and editing systems
- Optical and digitally captured optical microscopy systems
- Hipotronics High-Potential/Dielectric Withstand Voltage systems
- Field-portable digital waveform recording systems
- Waveform capture and analysis systems (LeCroy Wavepro 7300A and LeCroy L584M)
- Semiconductor parametric analysis systems (Tektronix 370/371A and HP 4145B)
- Temptronics Temperature Forcing Unit (±60 °C)
- Arbitrary waveform and signal generators
- High-accuracy General Purpose Interface Bus (GPIB)-capable multimeters
- Pico ammeter
- Milliohm meters
- GPIB-capable DC power supplies
- GPIB/DAQ Command and Control Software



*High-speed sequence*

*High-voltage splice failure*

- Investigated anomalies in Orbiter feed-through connectors and identified broken pins within the part caused by a misalignment of parts during assembly. Expanded the investigation to include all such parts in use or on shelves and secured replacement of all defective parts from the manufacturer at no cost.

- Analyzed a failed high-voltage cable in the Multi Mission Support Equipment at the Space Station Processing Facility. The findings led to changes in fabrication methodology and improved construction processes, thereby reducing electrical hazards.

## *Recent Notable Achievements*

- Performed several analyses of high-voltage splice failures that removed power from both launch pads. This analysis revealed workmanship problems, the corrections of which were instrumental in making the future rework of pad power more reliable. Additional splice failures have expanded the lab knowledge base and identified challenges in the splice construction process that will help make field electrical connections safer and more durable.

- Participated in an accident investigation of a Hangar AE Clean Room fire by providing forensic analysis expertise, which resulted in ascertaining the root cause of the fire.

- Performed radiographic inspection and optical microscopy to determine the nature of a fuse anomaly that threatened to delay rollout and processing of STS-100 (Endeavour). Quick identification allowed a timely rollout and saved $90,000 in additional retesting of the hardware.

- Developed a LabVIEW program to duplicate and automate a qualification test of an International Space Station flight temperature sensor module to characterize the sensor performance and stability over time. This restored confidence in the subject sensor module prior to flight.

- Developed a hardware test system and automated LabVIEW command and control software for the automated test and assessment of self-contained atmospheric protective ensemble (SCAPE) exhaust valves.

## *Staff Credentials*

- Electrical Engineers
- Electronics Technicians
- Mechanical Engineers

*Hangar AE clean room after fire*

*Laboratory Operator & POC:*
*NASA – Lawrence Ludwig*
*Mail Stop: NE-L1-E, KSC, FL 32899*
*Lawrence.L.Ludwig@nasa.gov, (321) 867-7049*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Instrumentation Systems Development Laboratory

The expertise of the Instrumentation Systems Development Laboratory focuses on Hazardous Gas Detection and Control Systems. The Hazardous Gas Detection group develops instruments using a mass spectrometer (MS) and other advanced analytical technologies to detect cryogenic propellant leakage in the Shuttle and other launch vehicles. In addition, the Transducer Development group develops and tests unique sensor-based measurement systems and evaluates commercially available sensors for compliance with strict Shuttle, International Space Station (ISS), Payloads, and KSC-specific design and performance requirements.

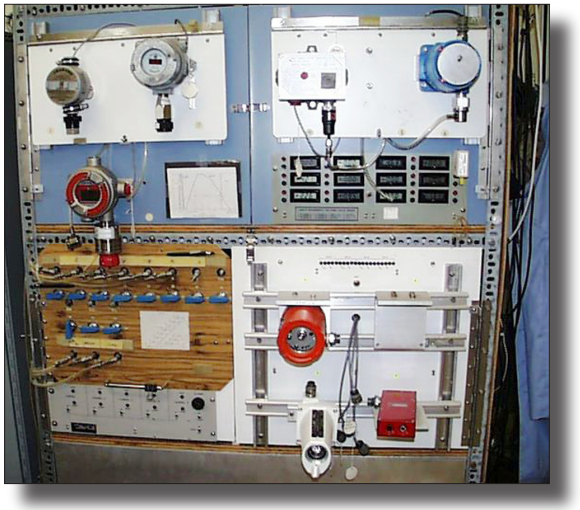
## Laboratory Services

- MS design and testing
- Gas sampling/detection system/analytical instrumentation design and testing
- Sensor- and transducer-based instrumentation system design (temperature, pressure, flow, strain, hydrogen gas detection, and hydrogen flame detection)
- Electromagnetic interference/compliance (EMI/EMC) testing
- Advanced computer-aided design (CAD), specifically for electrical sensor-based instrumentation system design

*Fluid baths*

*Temperature chambers*

*Gas flame detection*



## *Laboratory Assets & Specialized Equipment*

- Two high-precision, multichannel, gas-mixing systems
- Custom-built gas sensor testbed for delivering precise gas concentrations at variable temperatures and pressures/altitudes
- Residual gas analyzer mass spectrometer
- Gas chromatograph
- Vacuum pumps for ultralow vacuum production/gas sample delivery (various technologies)
- High-precision multimeters and voltage calibrators
- Secondary measurement transfer standards within areas of pressure and temperature
- High-precision equipment for generating pressure and temperature
- Closed-Loop Flow Calibration System (liquid or gas), 0.2 to 400 gallons per minute or up to 10 cubic feet per minute
- Five environmental temperature chambers
- Electromagnetic interference test chamber (20' × 20' and 8' × 14' anechoic chambers) and associated amplifiers and antennas for testing to MIL-STD-461, Revisions A through E

## *Recent Notable Achievements*

- Designed, fabricated, tested, and delivered the Hydrogen Umbilical Mass Spectrometer upgrades for operational use as a Criticality 1 ground support equipment (GSE) system.
- Upgrade and operational use of a custom miniaturized, ruggedized, MS-based gas analyzer system for portable monitoring of KSC purge gas supply quality and generation efficiency.
- Conducted investigative study in gas migration through instrumentation cable for hazardous-area cable use.
- Participated centrally in developing and implementing Kennedy Complex Control System, a multimillion-dollar, network-based programmable logic controller and Supervisory Control and Data Acquision (SCADA) system that monitors all facility systems at KSC.
- Developed and demonstrated of a fault-tolerant, PLC-based control system.
- Developed custom sensor signal conditioner for temperature, flow, and current-to-voltage signal conditioning.
- Developed Shuttle Orbiter Hang Angle Measurement system calibration station.
- Tested Vehicle Tracking Camera System, Hydrogen Leak Detector, PLCs, and Space-Based Telemetry and Range Safety (STARS) System for EMI/EMC.
- Completed drawing package of the Shuttle Intelligent Power Supply and Hydrogen Umbilical Mass Spectrometer (HUMS) systems.

## *Staff Credentials*

- Chemists
- Engineers
- Metrologist
- Transducer Test Engineers and Technicians
- CAD Designers

*Flow bench*

*Laboratory Operator & POCs:*
*NASA – Zachary Cline, Mail Stop: NE-E8, KSC, FL 32899*
*Zachary.K.Cline@nasa.gov, (321) 867-3723*

*Contractor – Tony Eckhoff, Mail Stop: ASRC-48,*
*KSC, FL 32899*
*Anthony.J.Eckhoff@nasa.gov, (321) 867-6751*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# Power Systems Laboratory

The Power Systems Laboratory supports the design and development of new ground support equipment (GSE) power systems, including equipment rack/subsystem power, DC power systems, vehicle special power, and battery-based systems. The laboratory provides single-shift coverage with personnel who have a broad base of experience with electric power systems and power electronics.

## Recent Notable Achievements

- Supported lightning research on power lines at Launch Pad 39B.
- Supported Shuttle Ground Special Power (GSP) DC power supply upgrade.

## Staff Credentials

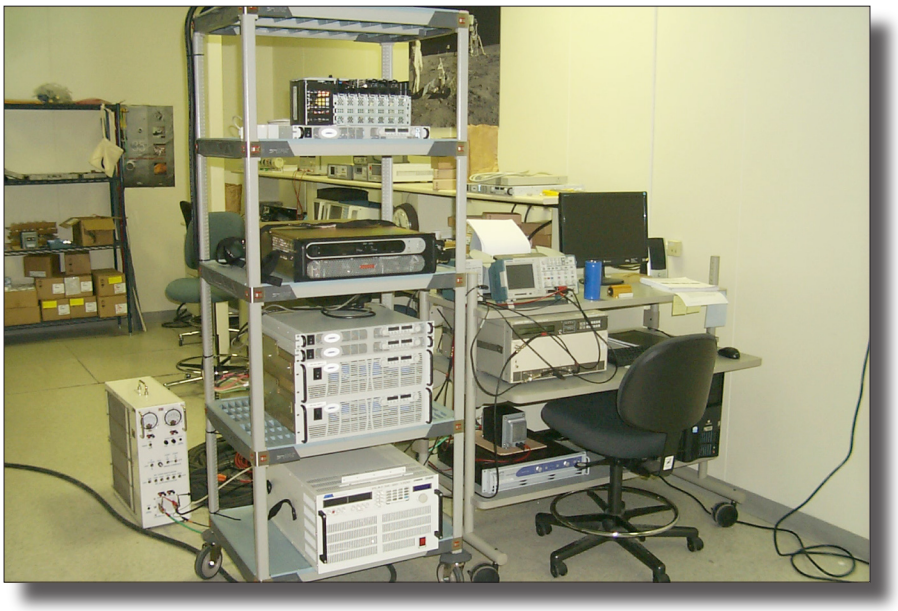
- Electrical Engineers

## Laboratory Services

- Frequency response analysis
  - Impedance measurements
  - Stability testing
- AC three-phase power analysis
  - Frequency
  - Power factor
  - Voltage
  - Current
  - Phase angles
  - Power (real, apparent, reactive)
- High potential (HIPOT) testing for single conductor
  - Dielectric breakdown test
  - Dielectric withstanding test
  - Insulation resistance test
- Transient DC power supply analysis
- Steady-state DC power supply analysis
- GSP design and development for vehicle and GSE

## *Laboratory Assets & Specialized Equipment*

- Frequency response analyzer – Portable unit with three-channel input and frequency range of 1 Hz to 2.2 MHz.
- Precision ICR meter – Portable inductance, capacitance, and resistance (ICR) unit has two channels capable of measuring inductors, capacitors, and resistors with a 20 Hz to 2 MHz frequency range.
- Power analyzer – Portable unit with three channels, capable of measuring frequency, power factor, voltage, current, phase angles, real power, apparent power, and reactive power.
- AC power converter – Converts 277/480 VAC to range of AC voltages, currents, and frequencies up to 30 kVA.
- DC active-load banks – A variety of portable DC active-load bank units with 18 kW, 7.5 kW, and 1.8 kW ratings.
- Current probes (high current) – Portable field units with maximum current ratings of 500 A and 300 A.
- Spectrum analyzer – Portable unit with frequency range of 3 Hz to 3.0 GHz.



*Laboratory Operator & POC:*
*NASA – Lashanda Slaiman, Mail Stop: NE-E7, KSC, FL 32899*
*Lashanda.G.Slaiman@nasa.gov, (321) 867-5594*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

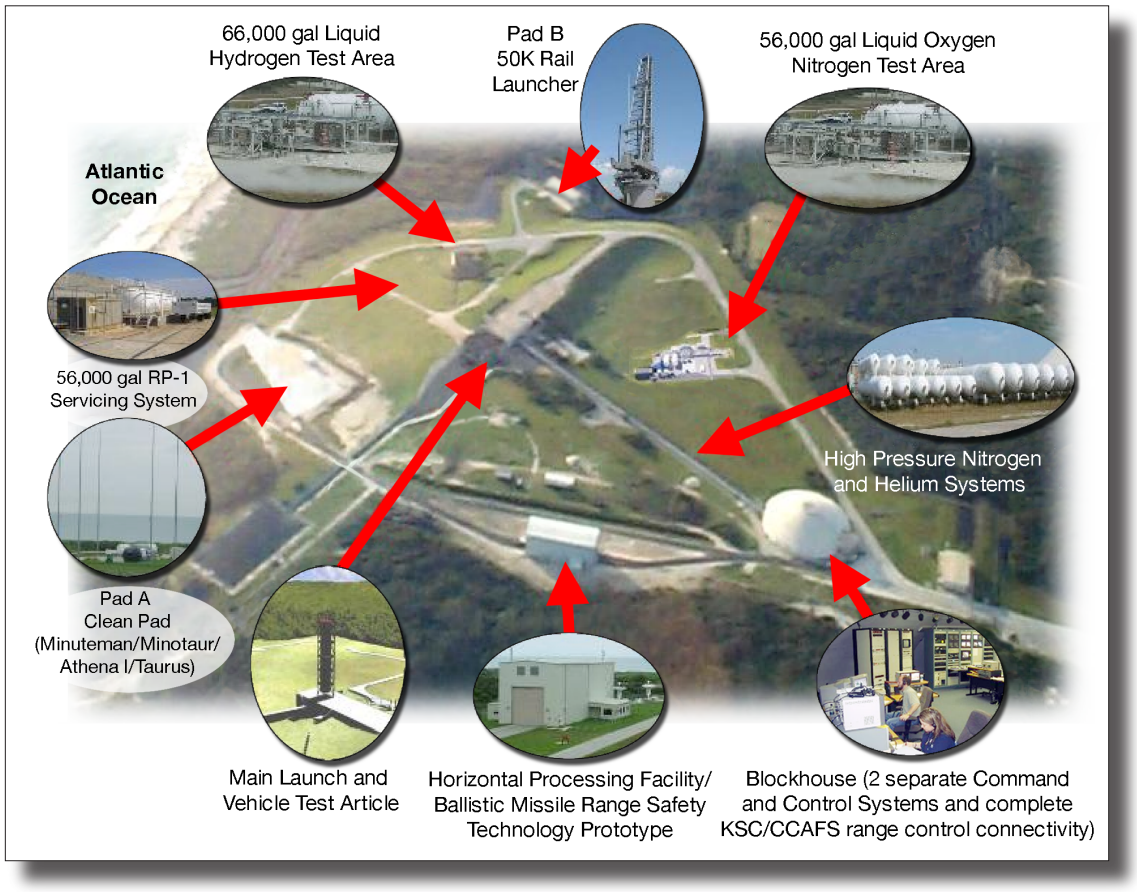
# *Fluids, Mechanisms, and Structures Laboratories*

# Advanced Technology Development Center

Kennedy Space Center has embarked upon the creation of a "Spaceport of the Future" test facility, the Advanced Technology Development Center (ATDC). ATDC will provide a national proving ground for the development, integration, demonstration, testing, and qualification of spaceport and range technologies. It can be thought of as a prototype spaceport where industry, Government, and academia can work together to improve the technology and safety of future space initiatives. ATDC hopes to provide a cost-effective, highly flexible, and capable testbed for a broad scope of activities ranging from development and testing of individual components to integration and testing of a wide variety of high-fidelity "iron birds" equipped with prototype systems that function as a complete flight system and can simulate various operational scenarios. ATDC will also concentrate on proving new processing technologies that will reduce the operations cost of launch processing activities.

ATDC will address the technology development arm of the up-front planning so it will improve the chances that a program will meet its goals within projected cost targets. The more we know about an advanced technology, the more we raise its individual technology readiness level and the more successfully we will apply that technology to a new project. That increased knowledge also promotes our ability to assess a technology's integration readiness level, which indicates the relative maturity of a technology to the subsystem to which it applies and helps decrease the technology risk for the program.

Much of the previous planning for the next-generation launch technologies has focused on the development of individual technologies that enable or enhance the next-generation launch architecture. Although not forgotten, planning and budgeting for the development of integrated systems has been deficient. To ensure program risks are minimized, integrated systems relating directly to the next-generation launch architecture must be developed, tested, certified, and validated. Thus, the concept of an integrated systems test facility (ISTF), like ATDC, that can provide an operationally responsive and relevant environment for the spaceport of the future is born. An ISTF can demonstrate, within ever-increasing maturity




*ATDC capability highlights (existing or currently in development)*

of integrated subsystems and systems, all future technologies required to support the spaceport of the future while maintaining the ability to adapt quickly and efficiently to new technologies. Everyday goals of enhanced reliability, availability, supportability, adaptability, scalability, maintainability, and safety are to be improved and demonstrated in an ISTF. Operability, fast turnaround time, and low cost are the desired results for the next-generation launch architecture and will be the product of an ISTF like the ATDC.

Located at Space Launch Complex (SLC) 20 at Cape Canaveral Air Force Air Force Station, ATDC can conduct safe, secure operations with gaseous nitrogen, liquid nitrogen, and liquid oxygen. Capabilities will be added later to support a full spectrum of "Spaceport of the Future" technologies and processes, including rapid-fill cryogenics, autocoupler technology, range resource development, and evolutionary launch vehicle processing.

## Laboratory Assets & Specialized Equipment

- Two 28,000 gal cryogenic dewars with associated loading, distribution, test, and disposal systems
- Gaseous nitrogen storage totaling over 400,000 standard cubic feet (operated to 3,000 psi) and associated distribution system
- Color video camera system with 8 fixed sites and 4 portable cameras.
- DICES 3 intercom system, area paging, remote fire alarm
- Blockhouse containing command and control and data acquisition systems
- Web-cam and video-streaming capabilities for video system
- Fabrication building
- Horizontal processing facility (owned by the Florida Air National Guard) with 15T bridge crane
- Two concrete test/launch pads (Minuteman 3-, Taurus-, and Minotaur-capable)
- Helium compressor

## Staff Credentials

Mechanical Engineers
Electrical Engineers
Cryogenic Engineers
Software Engineers
Project Managers

## Recent Notable Achievements

- A large volume liquid oxygen pump was successfully tested, where flow rates greater then 1,400 gpm were established without any harmonics, unexpected warming, or leak paths. This test begins the initial qualification testing of a new, high flow rate, ground support equipment (GSE) pump. Further testing will be conducted in coordination with other cryogenic test requirements.
- LC 20 staff provided supersonic gas generators, a test stand, and test area to accomplish the particle physics studies needed for NASA's return to the moon. Simulating lunar and Martian soil composition and atmosphere, the staff refined the distance, cratering effect, and debris flow field models necessary for *in situ* resource utilization (ISRU) on other planets.
- Wallops Flight Facility, in cooperation with KSC, selected LC 20 for the Liquid Fueling Facility (LFF). The LC 20 staff is tasked to design, field-test, and complete functional certification of the propellant pumping system, cryogenic super cooling, and software development.

*Laboratory Operator & POCs:*
*NASA – Steve Kyramarios, Mail Stop: KT-A1, KSC, FL 32899*
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*(321) 759-5028*

*Location:*
*Space Launch Complex (SLC 20), Cape Canaveral Air Force Station*

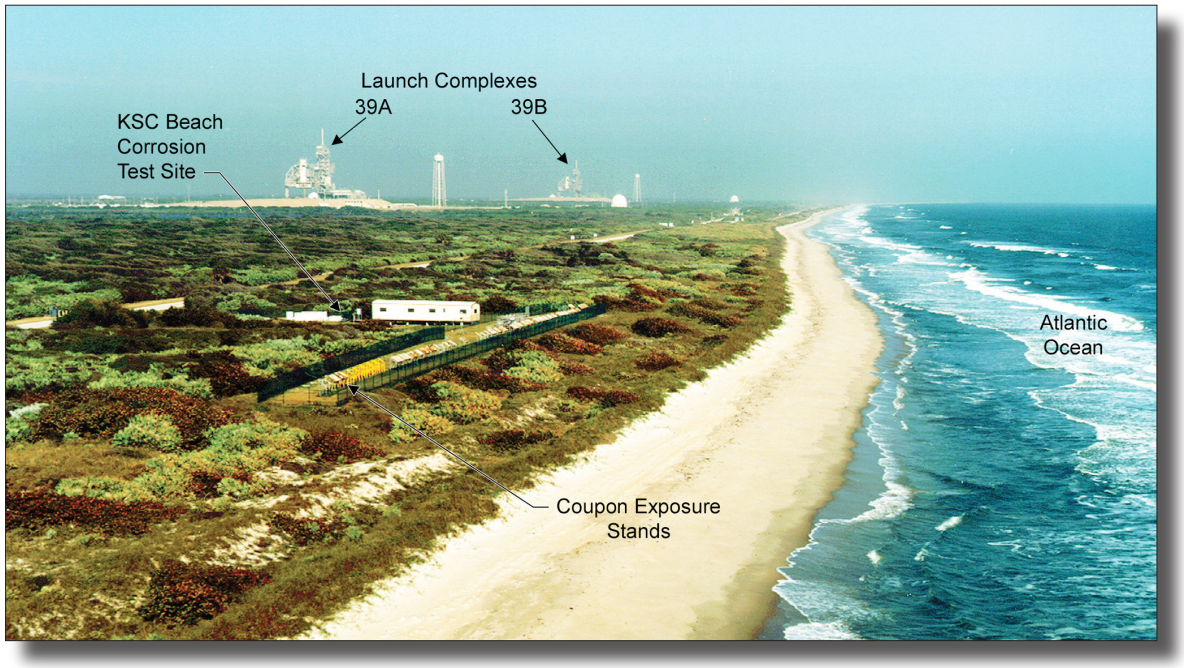
*Current configuration*

# Corrosion Technology Laboratory

The Corrosion Technology Laboratory provides corrosion expertise to NASA, its partners in other Government entities, private industry, and academia. The Corrosion Technology Laboratory has operated for over 35 years developing corrosion control techniques and detection methods; evaluating materials, coatings, and corrosion control methods; investigating material behavior; analyzing corrosion failures; and recommending approaches to mediate corrosion activity. These capabilities, along with an extensive historical database to support collected data, have served the space program, private industry, the Department of Transportation, and the U.S. military. The laboratory's uniqueness lies in the availability and combinations of extensive specialized services, trained personnel, and testing facilities. The laboratory consists of an atmospheric Beach Corrosion Test Site, an Electrochemistry Laboratory, a General Corrosion Laboratory, an Environmental Testing Laboratory, a Photodocumentation Laboratory, a Seawater Immersion Facility, and a complete weather station to support data analysis. The laboratory also has complete network connectivity for real-time data acquisition and Internet video.

## Laboratory Assets & Specialized Equipment

- Beach Corrosion Test Site: Most corrosive site in North America (qualifies as accelerated testing), including a full complement of configurable exposure stands, a test area for reinforced concrete, and a weather station supplying parameters to correlate with collected corrosion data.
- General Corrosion Laboratory: Fabrication of and experiments with coating formulation and evaluations, electrochemical analyses, and reinforced concrete.
- Electrochemistry Laboratory: A full complement of potentiostats and galvanostats to perform DC/AC experiments.
- Environmental Chamber Laboratory: Salt fog testing capabilities and QUV capabilities.
- Photodocumentation Laboratory: State-of-the-art cameras and microscopes to document corrosion and corrosion processes.
- Coating Application Laboratory: Coating measurements and evaluations.
- Paint Shop: Precision cleaning and sample preparation for coating evaluation.
- Seawater Immersion Facility: Consists of two immersion tanks with a continuous, once-through, filtered supply of seawater.
- Scanning Electron Microscopy Laboratory: Contains a JEOL 7500F Field-Emission-Scanning Electron Microscope (FE-SEM) capable of 1,000,000× magnification and a resolution of 1 nm. The FE-SEM is equipped with a Thermo Scientific Noran System Six energy dispersive spectrometer. The laboratory also contains a vacuum evaporator and sample-polishing equipment.




*Beach Corrosion Test Site with coupon exposure stands*

## Recent Notable Achievements

- Conducted a corrosion inhibitor study that resulted in the decision to apply a migrating corrosion inhibitor to NASA structures at KSC. This application will reduce the rate of corrosion and extend the life of structures by decades.
- Developing a "smart" coating system for the protection of metals.
- Tested and evaluated alternative coatings to the isocyanate products in use at KSC.
- Conducted seawater immersion and rinsedown studies of materials and welds for military applications.
- Evaluated corrosion mitigation techniques for flight and other critical International Space Station hardware.
- Conducted analysis to select a stainless-steel alloy to replace the corroding 300-series stainless-steel tubes at the Shuttle launch pads. This replacement alloy will extend the life of the tubing network by decades, reduce maintenance efforts, and increase safety.
- Tested chemical rinse agents that the U.S. Army is considering using to rinse its aircraft. This study spanned two years and tested four rinse agents on eight different materials. The resulting study was well received and brought worldwide recognition to the testbed.
- Authored numerous publications in the fields of corrosions and coatings. These publications are available online at <*http://corrosion.ksc.nasa.gov*>.

## Staff Credentials

- Chemical Engineers
- Chemists
- Corrosion Engineers
- Corrosion Technician

## Laboratory Services

- Electrochemistry; DC electrochemical experimentation and analysis (direct current methods and electrochemical impedance spectroscopy)
- Coating application, evaluation, inspection, and testing; sample preparation; and paint staging
- Field-emission scanning electron microscopy, energy-dispersive spectroscopy, and automated image analysis
- Experiment staging; real-time and accelerated corrosion testing
- Reinforced-concrete testing and analysis
- Accelerated corrosion and salt fog testing
- Seawater immersion
- Analysis of impingement and erosion corrosion, cavitation, and other velocity effects
- Metallurgical failure analysis, microchemical analysis, and material testing and evaluation
- Cathodic protection measurement/analysis
- Corrosion potential mapping
- Remote corrosion data acquisition/delivery
- Weather data acquisition/delivery

*Laboratory Operator & POCs:*
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*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Cryogenics Test Laboratory

The Cryogenics Test Laboratory provides comprehensive cryogenic expertise that serves the research and development and applied technology needs of both NASA and its commercial partners. Technology focus areas include thermal insulation systems; cryogenic component design, development, test, and evaluation; cryogenic pump design, development, test, and evaluation; low-temperature applications; and propellant servicing systems design, development, test, and evaluation. The objectives of the laboratory are to develop materials, produce new technology, integrate technology into new applications, and promote engineering services for energy-efficient storage, transfer, and use of cryogens and cryogenic propellants on Earth and in space. A cornerstone of the Cryogenics Test Laboratory is thermal insulation systems, which includes a family of research test cryostats. The laboratory also serves as a resource for innovative and timely solutions for our operational customers, as well as for the application of cross-cutting technologies to meet the needs of industry, other Federal agencies, and research institutions.

## Laboratory Assets & Specialized Equipment

- Liquid nitrogen supply systems for flow testing and laboratory operations
- Liquid helium supply system for flow testing and laboratory operations
- Liquid oxygen (LOx) supply system for flow testing and laboratory operations
- Liquid hydrogen ($LH_2$) supply system for flow testing and laboratory operations
- Specialized cryostats for insulation material testing
- High-vacuum pumping and instrumentation equipment
- Large-scale field-testing capability
- High-volume gaseous nitrogen flow testing
- Helium mass spectrometer leak testing
- Adaptable data acquisition and instrumentation capabilities
- Fully equipped general-use laboratory and high-bay work space
- Clean room work area

## Laboratory Services

- Thermal insulation systems
  - Research of new composite insulation materials
  - Development of high-performance insulation systems
  - Thermal performance testing under actual-use cryogenic-vacuum conditions
- Cryogenic components
  - Mechanical components design and development expertise
  - Sealing technology design expertise
  - Cryogenic pump design, testing, and evaluation
  - Cryogenic and gas quick disconnects
  - Operational use experience
  - Performance testing capabilities for valves, pumps, and sensors
- Low-temperature applications
  - Aerospace and industry applications
  - Energy applications for power transmission
  - Medical and biology applications
  - Integration of cryocoolers and refrigeration systems
- Propellant servicing systems
  - Energy-efficient propellant storage and transfer system design and development
  - Martian and lunar surface operations
  - Zero-boiloff technology
  - Subcooled propellants
  - Autonomous control
  - Hydrogen economy applications
  - Advanced energy technology
  - Solar thermal systems design, fabrication, and testing

## Staff Credentials

- Chemists
- Chemical Engineer
- Mechanical Engineer

## *Recent Notable Achievements*

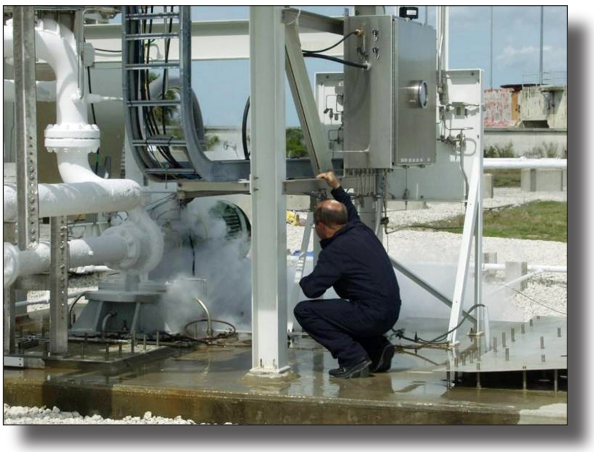
- STS-122 engine cutoff (ECO) sensor and feed-through time domain reflectometry and helium mass spectrometer troubleshooting and testing was performed by the Cryogenics Test Lab, resulting in the identification of the failure mode and repair and successful propellant loading and launch of the vehicle.

- New high-efficiency insulation systems were developed for a wide range of technology needs, including both flight hardware and ground system aerospace applications. Numerous patents and New Technology Reports resulted from this research.

- Bulk insulation performance and compaction testing was performed in two cryogenic spheres simulating the Launch Complex 39 LOx and $LH_2$ tanks. Numerous New Technology Reports resulted from this research.

- An innovative gate valve was designed, fabricated, and qualification-tested. A patent and New Technology Report resulted from this research.

- High-quality cryogenic expertise has been provided for practical solutions to commercial customer problems. This support included new LOx pump testing, qualification testing of valves, thermal performance testing of new insulation materials, and integration of cryogenic ground support equipment for new launch vehicles. This work has assisted our customers in their commercialization of new products and technologies.

*Laboratory Operator & POCs:*
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*Contractor – Walt Hatfield*
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*Location:*
*Cryogenics Test Laboratory (Bldg. M7-557)*

# Prototype Development Laboratory

The Prototype Development Laboratory performs quick-turnaround prototype development (often for solutions to one-of-a-kind problems), hardware fabrication and modifications, and component testing of ground support equipment (GSE) and flight hardware, and provides support to failure analyses performed by other NASA laboratories. The laboratory responds quickly to failures that occur during projects and launch/payload processing operations, with effective and timely design solutions and modifications. Laboratory personnel are highly skilled engineers and technicians trained in the latest computer-aided design (CAD) tools and machining processes, sheet metal fabrication, welding, cryogenics, high-pressure pneumatics testing, and electrical/electronics development.

## Laboratory Services

- Design
  - GSE and flight hardware design
  - CAD modeling (Pro/ENGINEER)
  - Engineering analysis
  - Prototype design (full-size and scale mechanisms)
- Development and Fabrication
  - GSE and flight hardware fabrication
  - CAD/manufacturing (CAM)
  - Welding (including structural, high-pressure, and cryogenic systems)
  - Rapid prototyping (fluid deposition modeling) and concept verification of hardware and components
  - Fluid and thermal systems (pneumatics, hydraulics)
  - Power and electrical systems
  - Digital and analog electronic systems
- Testing and Support
  - Data acquisition and instrumentation
  - Software programming (LabVIEW, Fortran)
  - Component testing

## Laboratory Assets & Specialized Equipment

- Water-jet cutting machine (4' × 4' and 6' × 11' capacity)
- Machining and sheet metal fabrication
  - Milling machines (3-axis, 20" × 40" cap) and (4-axis, 26" × 50"cap)
  - Mini milling machine (10" × 25" cap)
  - Lathes (18" and 20" swing over bed)
- Lathe, Monarch (13" and 17" swing over beds)
- Bridgeport milling machines with controllers (48" and 58" tables)
- Wire Electrical Discharge Machine (11" × 18" cap)
- Ram Electrical Discharge Machine (12" × 15" cap)
- 6,000-gal liquid nitrogen ($LN_2$) storage dewar for cryogenic testing
- 6,000-psi gaseous nitrogen ($GN_2$) system to support high-pressure test
- Pro/ENGINEER CAD/CAM software system
- Data acquisition software system
- Fused deposition modeling (16" × 14" × 16"), using ABS plastic, polycarbonate, or ABS/polycarbonate blend

## Recent Notable Achievements

- Designed, fabricated, tested, and certified inspection tools to inspect ball srut tie rod assembly (BSTRA) pivot balls *in situ* in the liquid oxygen ($LO_2$) and liquid hydrogen ($LH_2$) feedlines for the Orbiter's main engines.
- Designed, fabricated, tested, and certified a tool to remove a leftover double-punch piece of flow liner material from a flowlines groove in the $LH_2$ feedline of main engine #2 of OV-105.
- Assisted in the recovery and reconstruction of the Shuttle Columbia's debris. Designed and built a Lexan mockup of the leading edge of the wing (10% over scale), which was populated with Columbia debris to help determine the reentry burn path.
- Developed a Passive Acoustic Measurement System (PAMS), a sonar-type system with a higher frequency range than the sonar system emits, to eliminate interference from the ocean and river mammals. This system will assist in developing and cataloging sound signatures from a variety of fish species, as well as boats,

ships, and divers in the area. PAMS has the potential to support the Dept. of Homeland Security, U.S. Coast Guard, and Dept. of Defense for port protection and can also be used by environmental agencies to monitor fish populations in protected areas.

- Designed, fabricated, and tested an acoustic testing fixture and related hardware in support of the Launch Services Silent Fairing Program development of acoustic ablating materials.
- Modified out-of-tolerance Alpha Joint Integration System brackets on schedule, preventing payload delays and costly International Space Station (ISS) hardware returns to California.
- Designed, fabricated, and tested a tool capable of removing the cracks in the Shuttle Main Propulsion System flow liners, without generating any cutting debris.
- Corrected flight-critical interference fit on the sunshield of the mobile transporter (a safety device for the astronauts on the ISS) well ahead of schedule, with significant cost savings, and without affecting the outer ablative coating on the shield.
- Devised a chilldown process to allow for a changeout of a Shuttle power drive unit at the launch pad rather than rolling back to the Vehicle Assembly Building. This joint effort with the Cryogenics Test Laboratory prevented a launch delay and provided substantial cost savings.
- To prevent a launch delay, worked with engineers to design and test the real-time modification of 10 payload bearings in the Enhanced Universal Trunnion Attachment System that had an interference fit with the trunnions that transport the truss.
- Developed a prototype payload pressurization and vacuum cart that uses either high-pressure $GN_2$ or vacuum technology to fuel Expendable Launch Vehicle payloads.
- Helped develop a weight and center-of-gravity fixture for loading supply racks in the ISS mini pressurized logistics module with balanced weight distribution. Eight individual load cells were mounted in precise interrelationship to collect the correct weight data. Lab modifications to the prototype decreased the machining time needed to meet the schedule.

## *Staff Credentials*

- Electrical Technicians
- Mechanical Engineer
- Mechanical Technicians

*Panel Target Sunshield modifications for ISS*


*Using Pro-ENGINEER for flow liner crack anomalies*

*Verifying BSTRA Inspection System tooling*

*Laboratory Operator & POCs:*
*NASA – Todd Steinrock*
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*NASA – Harold McAmis*
*Mail Stop: NE-L3, KSC, FL 32899*
*Harold.R.McAmis@nasa.gov, (321) 867-1890*

*Location:*
*Prototype Shop (Bldg. M7-581)*

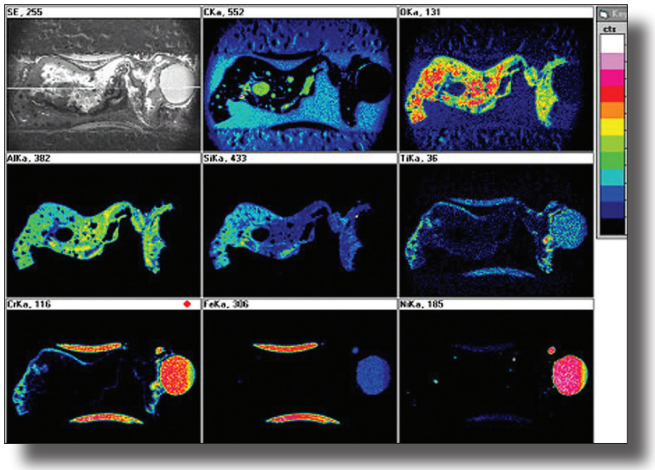
# Materials Failure Analysis Laboratory

The Materials Failure Analysis Laboratory provides failure analysis, forensic and accident investigation, and materials testing and evaluation services for metallic and nonmetallic materials and mechanical components used in aerospace flight hardware, ground support equipment (GSE), and facilities. Laboratory personnel also provide materials and processes (M&P) engineering consultation services (e.g., ASNT Level III radiography review and materials selection). Laboratory personnel have degrees in the following disciplines: metallurgical engineering, materials science and engineering, mechanical engineering, welding engineering, chemical engineering, and aerospace engineering.

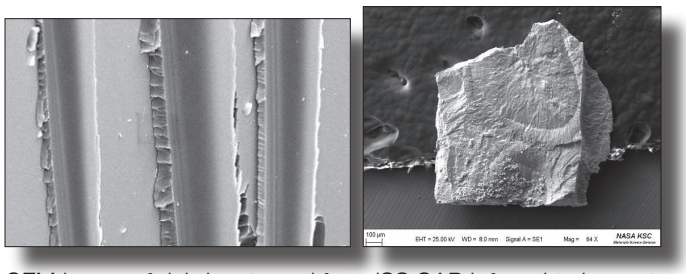
## Laboratory Services

- Metallic and nonmetallic materials failure and forensic analysis
- Accident and mishap investigation
- Scanning electron microscopy (SEM) and fractography
- NDE-ASNT Level III radiography certified
- Photodocumentation
- Corrosion evaluation, analysis, and prevention
- Visual, macroscopic, and stereomicroscopic examination
- Fractography
- Metallography
- Hardness testing (in the laboratory and field)
- Microhardness testing
- Conductivity testing
- Thermal analysis
- Pneumatic testing and simulation
- Metallurgical, polymeric, glass, and composite materials analysis
- Precision dissection and sectioning

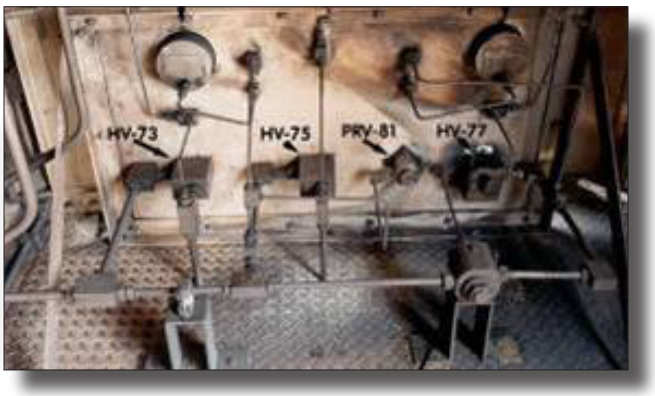
*Real-time failure analysis and metallurgical and chemical analysis support for the STS-107 investigation included debris assessment and evaluation*




*Energy-dispersive x-ray spectroscopy dot mapping of metallic "slag" specimens*



*SEM image of debris returned from ISS SARJ, found to be part of the nitrided 15-5 precipitation-hardened primary ring that was spalling from contact stress fatigue*




*Panel of a compressed-gas trailer that caught fire and resulted in a mishap investigation board being convened*

## Recent Notable Achievements

- Provided materials engineering, failure analysis, and materials evaluation for the following investigations:
  - STS-122 engine cutoff (ECO) sensor liquid hydrogen ($LH_2$) feed-through connector analysis support
  - ISS Solar Alpha Rotary Joint (SARJ) primary ring debris analysis
  - STS-119 on-orbit tile damage analysis
  - OV-103 right-hand main landing gear compressed o-ring analyses
  - Failure and replacement of the Crawler/Transporter shoes
  - STS-121 bipod bolt investigation
  - STS-107 flow liner investigation
  - Ball strut tie rod assembly (BSTRA) ball investigation
  - Launch Complex 39A PCR glass light fixture failure analysis
- Participated in several notable accident investigations by providing materials and forensic investigation expertise, including:
  - The Columbia Accident Investigation Board, both in the reconstruction hangar and lab, performing debris assessment, real-time failure analysis, and metallurgical and nonmetallic analysis
  - The fire investigation of Compressed-Gas Trailer GT-82; performed disassembly, inspection, and functional and chemical analysis of trailer components, helping to determine the root cause of the mishap
  - The investigation of the catastrophic loss of U.S. Air Force Delta 2 Mission 241
  - Space Launch Complex 2 West detonation at Vandenberg Air Force Base (AFB) during launch of the Delta II rocket carrying the CALYPSO/CLOUDSAT satellite
  - Space Launch Complex 2 launch mount spacer at Vandenberg AFB
- Provided M&P evaluations to customers, such as:
  - Shuttle: The inspection and resolution of the composite overwrap pressure vessel wrinkling problem
  - Launch Services Program: Developing and interpreting the nondestructive inspection and acceptance criteria for the Alenia tank weld problem
  - International Space Station: Rapid response to SARJ debris failure analysis returned from orbit on STS-120
  - Constellation: Helping develop and interpret nondestructive evaluation techniques for Crew Exploration Vehicle thermal protection systems; helping develop M&P requirements for docking hardware between Orion and the ISS

## Laboratory Assets & Specialized Equipment

- Environmental variable pressure scanning electron microscope with Peltier cold stage for wet sample analysis
- Energy-dispersive x-ray spectrometer
- Confocal laser microscope
- Stereomicroscopes with extended depth-of-field imaging
- Metallurgical microscopes
- High-precision dissection facility
- Metallographic saw, mounting press, grinder, polisher, and etcher
- Automatic microhardness tester
- High-definition/high-resolution digital cameras
- Coating thickness gauge
- Differential scanning calorimeter (DSC)
- Thermogravimetric analyzer (TGA)
- Simultaneous DSC-TGA
- Pneumatic test panel
- Electrical conductivity meter
- Equotip portable hardness tester
- Dynamic mechanical analyzer
- Thermomechanical analyzer
- Radiographic viewing center
- Borescope

## Staff Credentials

- Failure Analysts
- General Engineer
- Materials Science and Engineering Failure Analysts (metallic)
- Mechanical Engineer
- Mechanical Engineering Failure Analyst
- Metallurgical Engineers
- Professional Engineers

*Laboratory Operator & POC:*
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*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Physical Test and Analysis Laboratory

The Physical Test and Analysis Laboratory provides a range of physical testing of materials and includes several laboratory areas. The Environmental Testing Laboratory provides chambers and equipment to simulate a range of temperature, vacuum, and humidity conditions for testing flight hardware under space conditions, vacuum-drying materials, and performing outgassing conditioning of materials to be used in space. The Materials Testing and Data Collection Laboratory performs flammability, materials compatibility, and electrostatics testing to support the KSC Ground Operations Safety Plan. The Physical Properties Laboratory performs material, mechanical, physical, and environmental testing of ground support equipment and flight hardware. Tests include tensile, compression, fatigue, flammability, electrostatic discharge, materials compatibility, and thermal vacuum chamber testing (including bake-outs of flight hardware to control outgassing). The Vibration Analysis Laboratory offers vibration and shock testing with two shaker tables and high-speed photography.

*High-vacuum bell jar*

## Laboratory Services

- Tensile, compression, and fatigue testing
- Flammability, electrostatic discharge, and hypergol compatibility material evaluation
- Thermal vacuum and environmental chamber testing
- Vibration and shock testing
- Lubricant testing
- Hydraulic testing
- Materials evaluation

*Instron Universal Test Machine*

## Staff Credentials

- Corrosion Engineer
- Materials Engineer
- Mechanical Engineer

## *Recent Notable Achievements*

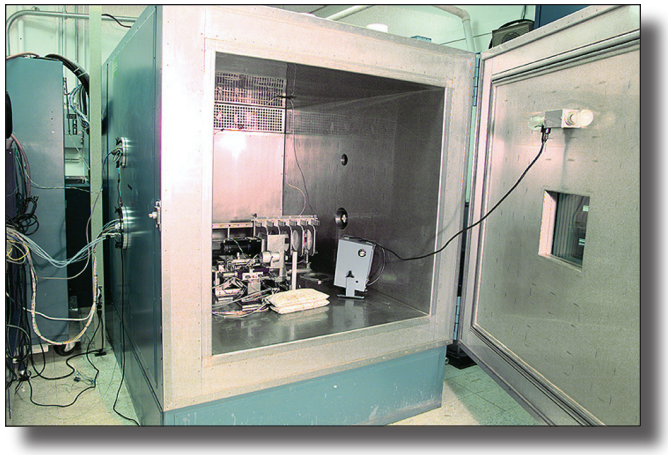
- Ongoing effort to revise NASA-STD-5005, involving personnel from KSC, Marshall Space Flight Center, and Johnson Space Center. KSC personnel are responsible for the Materials and Processes Section.

- Performed impact, hypergol compatibility, abrasion, electrostatic discharge, and flammability testing on new face shield material for propellant handler's ensemble.

- Provided vibration testing and analysis for the Delta II RS-27A-51 Hoop Band Weld Investigation.

- Performed random vibration testing on the UH-1 helicopter mount rack for LifePak 12 defibrillator.

- Payload isolation dampers for Pegasus/AIM were vibration-tested using a high-center-of-gravity mass model simulating the spacecraft.



*Large thermal vacuum chamber*

## *Laboratory Assets & Specialized Equipment*

- Walk-in environmental chamber
- Thermal, vacuum, and environmental chambers
- High-vacuum bell jar
- Instron and MTS Universal Test Machines
- Cryostats
- Triboelectric electrostatic discharge measurement system
- Vibration and shock tables
- Hydraulic test bench

*Shaker table with high-center-of-gravity mass fixture*

*Laboratory Operator & POC:*
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*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Mechanical, Structural, and Controls Development Laboratory

The Mechanical, Structural, and Controls Development Laboratory supports a wide spectrum of testing and development activities. This capability was established in the 1970s to provide full-scale qualification of Space Shuttle umbilicals and T-0 release mechanisms. Located at the Launch Equipment Test Facility (LETF), the laboratory has leveraged these unique test capabilities into a versatile test and development complex that supports a wide range of operational programs at KSC. Ground support equipment (GSE) is tested and certified in a large outdoor area surrounded by test support facilities. These support functions include comprehensive mechanical and electrical fabrication and environmentally controlled assembly and development. The lab's combination of unique test systems and its experienced technical staff make it a "one-stop shop" for performing difficult and hazardous testing.

## Laboratory Services

- Complete machining and fabrication services, including computer numerically controlled (CNC) vertical mills, lathes, and 5-axis-wire electrical discharge machining, tube bending, flaring, and orbital welding up to 2 inches in diameter. Welding services include sheet metal, structural, power piping, and tubing using various materials and processes.
- Proof-load testing – Vertical: up to 600 tons, system envelope 27' 8" H × 18' 8" W; Horizontal: up to 220 tons, system envelope 54', can accommodate up to 66 feet with adapters.
- Waterflow testing with two independent loops.
- Fabrication, assembly, and qualification testing of umbilicals using a liquid hydrogen ($LH_2$)/liquid nitrogen ($LN_2$) system adjacent to a liftoff simulator and random motion simulator.
- Rapid prototyping of tool profiles from computer-aided design (CAD) files.
- Expertise in Pro/ENGINEER, MicroStation, and other CAD programs; failure effects analysis; and computational fluid dynamics analysis.
- Data acquisition design, installation, and analysis capabilities.
- Fabrication, assembly, and test capabilities for component-level qualification of a wide variety of equipment.

*Test fixture used to proof-load lifting fixtures such as clevises, straps, and spreader beams*

## Laboratory Assets & Specialized Equipment

- 600 ton vertical, 250 ton horizontal test fixture
- Holddown post test fixture capable of 1.6 million pounds of vertical compression, 700,000 lb of vertical tension, and 500,000 lb of horizontal tension
- $LH_2$ system
- Waterflow test setup consisting of closed, concentric flow loops – a 400 gpm, 2 inch loop, and a 1,700 gpm, 3 inch loop with 3 inch and 6 inch sections
- Machine, welding, pneumatics, sheet metal, and cable shops
- Data acquisition laboratory
- GSE development laboratory
- Liftoff simulator
- Control room
- Fast-response instrumentation van
- Portable data acquisition systems

## Staff Credentials

- Electrical Engineers
- Electrical Technicians
- Instrumentation Technicians
- Machinists
- Mechanists
- Mechanical Engineers
- Mechanical Technicians
- Pneumatic Technicians
- Welders

## *Recent Notable Achievements*

- Performed Space Shuttle qualification testing for all tail service masts, External Tank vent arms, gaseous oxygen vent arms, and post-Challenger Solid Rocket Booster (SRB) joint heater umbilicals. All umbilicals were tested in a high-fidelity environment simulating vehicle motion through fueling, wind loading, and Space Shuttle main engine ignition and at cryogenic temperatures where applicable.
- Tested the holddown post aluminum foam debris containment device, a replacement for the current lead energy-absorbing material, including exploring skewed firing of the two booster cartridges used to separate the frangible nut. This resulted in insight into a possible contributor to stud hang-ups. A skew of 300+ milliseconds resulted in repeatable stud exit velocity insufficient to break the frangible link between the blast container plunger and stud.
- Supported the STS-107 investigation in the reconstruction of the leading reinforced carbon-carbon (RCC) panels. Designed and fabricated 6 RCC stands containing 13 panels and the leading-edge Lexan support structure in 8 weeks.
- Performed qualification testing of the four Atlas V autocoupler umbilicals that provide the conduit between the Pad Equipment Building and the Mobile Launcher Platform.
- Performed a qualification test of the Delta IV swing arm and vehicle erection hardware, the NASA-designed and -fabricated Environmental Control System quick disconnect, and the hydrogen entrapment system.
- Assembled and tested the Space Station Processing Facility Rack Insertion Device.
- Tested the composite nose cone gaseous oxygen vent hood prior to first use to determine the thermal expansion characteristics of the existing foam insulation relative to the composite nose cone.
- Tested the Haulover Canal Bridge to measure vibration and stress on critical structural members for bridge certification.
- Collected strain gauge data during Space Shuttle Crawler operation to evaluate stress and vibration affecting the commodities tunnel under the crawlerway.
- Designed and built a high-fidelity test setup to simulate the transfer of ammonia from the Space Station Processing Facility systems to the Multi-Purpose Logistics Module flight hardware prior to final design and procurement award.
- Tested the Main Propulsion System liquid oxygen/liquid hydrogen replenish valve and developed a bellows-type stem configuration that eliminated all stem leaks.
- Collaborated with NASA and United Space Alliance to design, build, and implement a Circularity Measurement Tool – a self-contained, handheld, lightweight device to measure the SRB shape prior to mating segments.

*Reconstruction of the leading RCC panels in support of the STS-107 Investigation*

*Complete machining and fabrication facility*

*Laboratory Operator & POCs:*
*NASA – Eric Ernst*
*Mail Stop: NE-D1, KSC, FL 32899*
*Eric.W.Ernst@nasa.gov, (321) 867-2732*

*Contractor – Rick Van Gilder*
*Mail Stop: ASRC-3, KSC, FL 32899*
*Richard.M.Vangilder@nasa.gov, (321) 867-2526*

*Location:*
*Launch Equipment Test Facility (Bldg. M7-505)*

# Metrology Laboratory

The Metrology Laboratory provides rapid metrological analyses for critical measurements of flight hardware and ground support equipment (GSE) and in support of failure analyses performed by other NASA/KSC laboratories. In-house metrology allows independent verification of quality, alignment, fit, and finish of critical flight hardware and GSE upon their arrival at KSC, as well as dimensional analyses of anomalies (e.g., scratches on sealing surfaces, leaks, high running torques, and mechanical malfunctions) encountered during flight hardware processing.

*Brown and Sharpe Coordinate Measuring Machine*

## Laboratory Assets & Specialized Equipment

- Johnson Threadview Inspection System
- Brown and Sharpe Image (computer-controlled) coordinate measuring machine (CMM)
- Romer Infinite Portable CMM
- Micro-Vu Optical CMM
- Mahr Surface Contour System
- Pratt and Whitney Super Micrometer
- Variety of hand tools (micrometers, calipers, height gauges)
- 6' × 8' Tru-Stone granite table

## Laboratory Services

- Precision measurement and dimensional analysis
- Alignment and threaded-fastener gauging
- Mold impressions of scratches, cracks, and defects
- Contractual and specification compliance measurements

## Staff Credentials

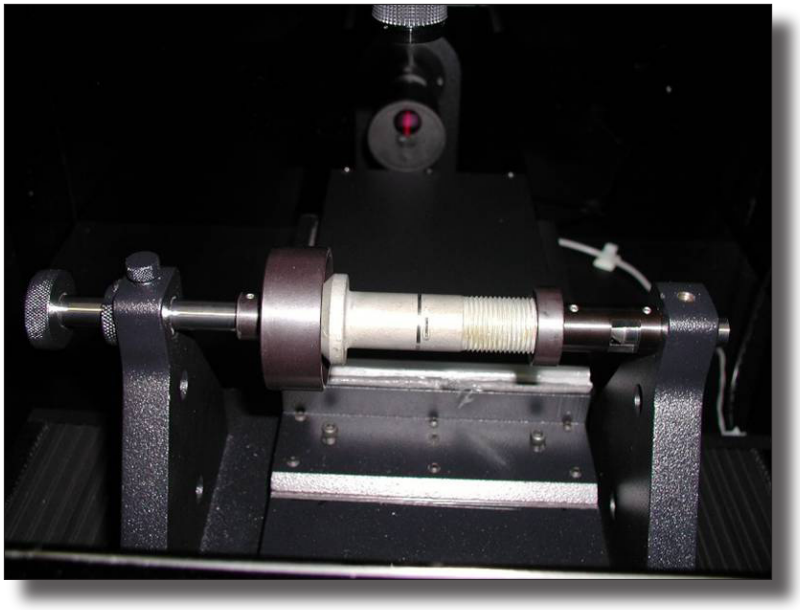
- Mechanical Engineer
- General Engineering Professional Engineer (PE)
- Technician

## *Recent Notable Achievements*

- Provided timely dimensional analysis on STS-121 Main Propulsion System/Space Shuttle Main Engine fuel and oxidizer interface seals, Orbiter window bolts, External Tank hydrogen tank phenolic shim, and Mobile Launcher Platform crawler bushings.

- Provided rapid, real-time dimensional analysis in support of the International Space Station for measurement and evaluations of trunnions, trunnion pins, mold impression anomalies, Multi-Purpose Logistics Module surface imperfections, and 182 bolts for mission 1J-A.

- Provided dimensional analysis to the U.S. Navy on inertial measuring unit GSE handling ring and associated fasteners; performed dimensional analysis of cadmium-plated bolts for the NASA Office of the Inspector General.



*Johnson Threadview Inspection System*

*Laboratory Operator & POC:*
*NASA – Roy King, Mail Stop: NE-L1-R, KSC, FL 32899*
*Roystan.J.King@nasa.gov, (321) 867-8014*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Nondestructive Evaluation Laboratory

The Nondestructive Evaluation (NDE) Laboratory supports the aerospace community by performing nondestructive testing (NDT) on numerous flight hardware and ground support equipment (GSE) components. Since the 1960s, the NDE Laboratory has performed the majority of the NDE tasks at KSC, as well as supported numerous task requirements for Cape Canaveral Air Force Station and Patrick Air Force Base. The laboratory provides two-shift coverage with personnel who have a broad base of NDE experience that includes offshore construction platforms, pipelines, and nuclear/chemical power plants. NDE Laboratory customers receive immediate response and support from a technical staff with wide and diverse fields of expertise.

## Laboratory Services

- Magnetic particle inspection: visible and fluorescent particles, including dry and wet methods
- Dye penetrant inspections: visible and fluorescent methods
- Leak detection: bubble check, mass spectrometer, and ultrasonic
- Computed tomography
- Radiography (gamma and X-ray)
- Ultrasonic inspection: flaw, high-resolution thickness, bond integrity, and bolt torque elongation
- Infrared: qualitative and quantitative
- Eddy current inspection: flaw detection, coating thickness, and conductivity measurements
- Microfocus real-time radiography
- American Welding Society-certified weld inspections
- American Society of Nondestructive Testing (ASNT)-certified NDE Level III engineering consulting
- Thermal insulation system development and testing
- Prototype component design, fabrication, and testing
- Cryogenic system and instrumentation design and testing
- Propellant systems planning and integration
- High-vacuum measurement and leak detection
- Low-temperature applications

## Laboratory Assets & Specialized Equipment

- X-ray units – Portable field units with 100 kV and 225 kV penetrating ability, permitting penetration up to ~1.5" of steel or its equivalent; and a 420 kV stationary lab unit capable of penetrating 3" of steel or its equivalent.
- Gamma ray devices – Ir 192 and Co 60 sources capable of penetrating approximately 9" of steel or its equivalent.
- Micro focus 160 kV real-time unit – capable of detecting flaws down to 5 µm while allowing remote part manipulation and rotation. Part areas may be magnified up to 100 × without loss of spatial resolution.
- Computed tomography – Utilizes a Co 60 source and a 450 kV x-ray machine, allowing the examination of internal structure and material integrity of a variety of space components.
- Ultrasonic units – Capable of penetrating different material types and measuring thicknesses down to .010 inch. The UT units can examine weldments and machined materials for flaws using various sound angles and straight beams. Other units can inspect honeycomb structures for bond integrity.
- Leak detection units – Portable mass spectrometer helium leak detection systems capable of detecting leaks as small as $10^{-10}$ atm-cc/s.
- Magnetic particle units – Portable and stationary equipment with both AC and DC capabilities.
- Dye penetrant units – Portable kits and stationary bench unit with fluorescent and visible dye capabilities.
- Infrared units – Portable field units can detect moisture intrusion in Shuttle tiles and facility structures and can detect overheating of electrical components. These units can detect temperature differences as small as 2% and can provide instant thermal analysis.
- Remote visual inspection/closed-circuit television (CCTV) units – Portable units with small- to medium-sized probes down to 7 mm diameter and lengths up to 75' can be inserted into small crevices and holes for interior inspection and measurement analysis of objects, welds, foreign object debris (FOD), etc. CCTV units with accessories can record data on VHS tape and computer storage disk.
- Eddy current units – Portable units that can detect and identify material flaws, sort alloys, detect conductivity changes, and measure coating thicknesses.

## Recent Notable Achievements

- The NDE Lab contributes to mission success by performing hundreds of examinations each year on critical lifting hardware, support structures, pressure vessels, and piping to ensure their integrity and to preclude catastrophic failures that could result in injury or loss of flight hardware.
- The NDE Lab supports each Shuttle launch and landing with infrared imaging of the Shuttle in the event of a return to launch site and during end of mission.
- The NDE Lab supports Shuttle processing major milestones with visual inspections during the Shuttle's transfer to the pad (IOMI A5314) and with ultrasonic bolt elongation measurements during the Orbiter-to-External Tank mate (IOMI S0004).
- Performed computerized tomography evaluations of reinforced carbon-carbon (RCC) panels in support of return-to-flight activities.
- Supported the STS-107 investigation by radiographing numerous debris parts and the Shuttle tires, using real-time digital and conventional film imaging.
- Identified a critical anomaly outside the area of interest during a periodic NASA helicopter radiographic inspection.
- Provided NDE engineering and radiography support for the Mars Odyssey Pryo valve investigation.
- Provided infrared data and operational support for an investigation of the Shuttle's S-band antenna's vulcanized bonding interface.
- Identified flow liner cracking in the Shuttle Main Propulsion System, using eddy current testing, and provided radiographic support for flow liner weld repairs.
- Provided magnetic particle, eddy current, and CCTV support for the investigation of JEL bearing cracking associated with STS Crawlers No. 1 and No. 2.
- Identified the malfunctioning internal components of the International Space Station brake docking mechanism.
- Provided extensive radiographic FOD inspection in support of the Delta II program.
- Performed numerous NDE methods in support of the Titan pressure vessel recertification program.
- Performed ultrasonic high-resolution thickness measurements and reviewed radiographs for NASA in support of Delta II missions, including Stereo, Themis, Dawn, Phoenix, STSS, Cosmo2, and Glast.
- Provided NDE consultations, engineering, extensive radiography, and computed tomography support to NASA Engineering Safety Center for evaluation and analysis of Primary Carrier Assembly units.
- Provided NDE consultations, engineering, and presentations to NASA KSC, JSC, United Space Alliance, and Boeing regarding modification and implementation of high-speed, real-time infrared thermography inspection on Shuttle Fleet Avionics Fire Bottles for United Space Alliance and NASA Environmental Controled Life Support System (ECLSS) Engineering.
- Provided high-speed, real-time infrared thermography support to United Space Alliance Engineering in the Failure Analysis Lab regarding Shuttle Discovery engine cutoff (ECO) sensor line replacement units.
- Provided infrared thermography support to NASA and United Space Alliance Mechanical and Fluids Engineering teams during end-of-mission operations for STS-115 specific to $H_2O$ spray boiler No. 3, Auxiliary Power Units (APUs), MLG, and Thermal Protection System (TPS).
- Provided magnetic particle examinations on the Shuttle Transporter Crawler cleats, sprockets, and rollers and CCTV visual examination and recording of the internal surfaces of the cleats.

## Staff Credentials

- Level III NDE Engineers
- Level II NDT Technicians
- Computed Tomography Engineers

*Laboratory Operator & POC:*
*Contractor – Kenneth Walla*
*Mail Stop: ISC 6200, KSC, FL 32899*
*Kenneth.C.Walla@nasa.gov, (321) 861-0620*

*Location:*
*Converter/Compressor Operations Bldg. (K7-569)*

# Standards and Calibration Laboratory

The Standards and Calibration Laboratory provides metrology services to NASA KSC and contractor organizations. The Reference Standards Laboratory maintains the most accurate measurement standards within NASA KSC and provides traceability to the National Institute of Standards and Technology (NIST) to ensure consistency of measurement and test results. The Reference Standards Laboratory also pivots various NASA measurement assurance programs (MAPs), sharing traceability among Centers and thereby reducing costs. The Calibration Laboratory calibrates and repairs a wide variety of measuring and test instrumentation. Laboratory personnel are highly skilled measurement scientists and calibration technicians with in-depth knowledge of how measuring devices work, what error sources affect them, and how to perform accurate measurements.

## Laboratory Services

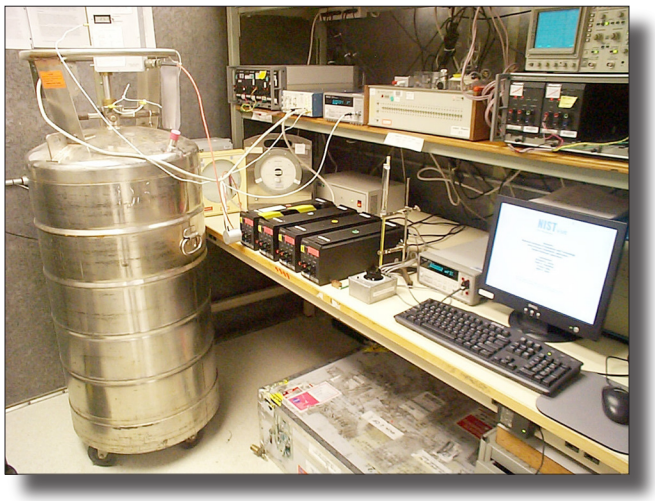
- Calibration of reference and working standards
- Metrology engineering services
- Calibration and repair of measuring and test equipment
- Precision cleaning and oxygen certification of pressure and flow gauges
- Development, operation, and maintenance of Metrology Information System and automated calibration processes
- In-place calibration of immovable equipment and systems
- Identification and validation of offsite calibration service providers
- Support of traceability for all seven fundamental SI units

## Laboratory Assets & Specialized Equipment

- Primary temperature standards (argon through silver) for calibration of temperature sensors
- Resistance Calibration System accurate to <±0.2 ppm
- Hydraulic Force Calibration System (100 lbf to 100,000 lbf)
- Very Low-Pressure Primary Standard [10 mPa to 15 kPa, accuracy ±(30 ppm +25 mPa)]
- Josephson Voltage Standard (Primary) system accurate to ±0.02 ppm from 0 VDC to 10 VDC
- Helium Leak Calibration System ($10^{-9}$ to $10^{-7}$ std cc/s) with capability for temperature characterization of test items
- Dual Pressure Humidity Standard (accurate to ±0.25% relative humidity)
- GPS/Cesium Time Standard accurate to $<\pm 2\times10^{-12}$
- Class 100,000 clean room and CFC-113 solvent workstations for gauge cleaning
- Automated oscilloscope calibration workstation
- Automated digital multimeter calibration workstation
- Gravimetric Mass Flow Calibration System: 10 standard cubic centimeters per minute to 100 standard liters per minute, accurate to ≤0.2% of reading

## *Recent Notable Achievements*

- Provided reliability data to the Return to Flight Task Group at Johnson Space Center evaluating impact of extended usage on reliability of measuring and test equipment on board the International Space Station (ISS). No other NASA Center had data available for the subject instrumentation.
- Field-tested and implemented the NASA portable Josephson Voltage Standard, jointly developed by NASA, the Department of Energy, and NIST, to make these standards more widely available. This project provided NASA with a portable voltage standard based on fundamental physical constants ($h$ and $e$) that the laboratory continues to operate and maintain.
- Implemented statistical process control for many measurement systems within the laboratory to improve reliability of measurements and confidence in the uncertainties being assigned to reference standards.
- Developed, validated, and implemented over 300 automated and semiautomated calibration procedures to reduce calibration costs and increase the consistency of test results.
- Organized and operated MAPs for resistance and voltage with other NASA Centers to validate the accuracy of measurement systems and ensure consistency of measurements across NASA Centers. The laboratory maintains the transportable measurement standards used in these MAPs and has characterized them for pressure and temperature coefficients and drift to provide better uncertainties to participating NASA Centers.
- Obtained, refurbished, and upgraded a surplus vacuum chamber to serve as a secondary chamber at KSC, which saved the cost of a new second chamber, improved the laboratory's throughput, and eliminated delays caused by the high volume of vacuum transducers being supported.
- Operated, maintained, and upgraded the NASA Helium Leak Calibration System, which provides calibrated, NIST-traceable helium leak standards used for leak testing by Shuttle, ISS, and Payloads at KSC and by other NASA Centers. This upgrade included replacing the mass spectrometer.
- Provided priority service with equipment calibration and turnaround in less than 5 days over 100 times in the last year in support of Shuttle, Payload, and ISS processing schedules.



## *Staff Credentials*

- Computer Science Engineers
- Electrical Engineers
- Mechanical Engineers
- Technicians

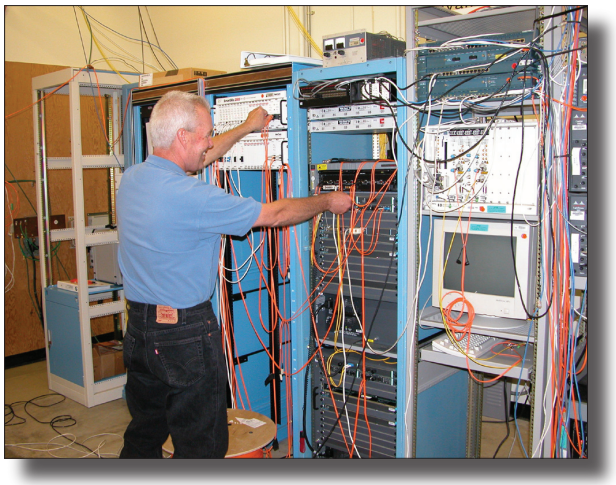
*Laboratory Operator & POC:*
*Contractor – Perry King, Mail Stop: ISC 6175,*
*KSC, FL 32899, Perry.C.King@nasa.gov, (321) 494-2504*

*Location:*
*Physical Calibrations: KSC, Central Instrumentation Facility (Bldg. M6-342)*
*Electrical Calibrations: Patrick Air Force Base (Bldg. 981)*

# *Information Technology and Communications Laboratories*

# Advanced Network Development Laboratory

For nearly 20 years the Advanced Network Development (AND) Laboratory has led the research, analysis, design, development, and deployment of all next-generation telecommunications transmission systems for KSC. The laboratory provides a testbed consisting of past, current, and next-generation systems combined with technical expertise, thus enabling research, analysis, and development activities directed at obtaining maximum efficiency from KSC's current communications investment, while providing the appropriate and optimal level of technology infusion. Laboratory personnel can support research and analysis in virtually any communications environment, including Ethernet, T-Carriers, synchronous optical network (SONET), and asychronous transfer mode (ATM). The AND Laboratory is the only development resource at KSC with the skills and resources necessary to identify technology and to investigate and manage the resulting deployment of large, complex communications systems. This laboratory is uniquely suited for testing and evaluating industry products for use at KSC in a testbed that accurately reflects the KSC operating environment and eliminates costs associated with the late identification of incompatibilities.



*Advanced network development*

## Laboratory Assets & Specialized Equipment

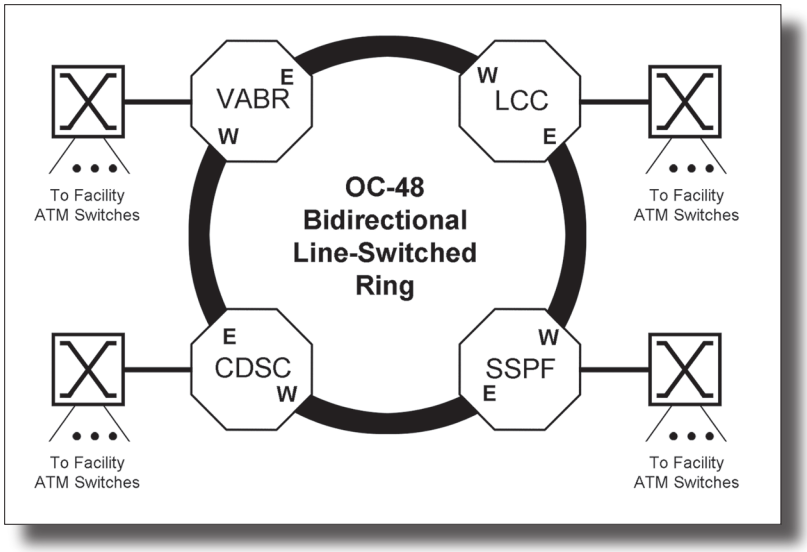
- Analyzers (HP Internet ATM Advisor, Acterna SONET, and Spirent TestCenter)
- ATM switches (Cisco and Fore Systems)
- Switch/routers (Cisco, Foundry, Extreme, Riverstone)
- 3 GB lightwave component analyzer
- 3.2 GB and 700 MB bit error rate testers
- ClearSight network analyzer/sniffer

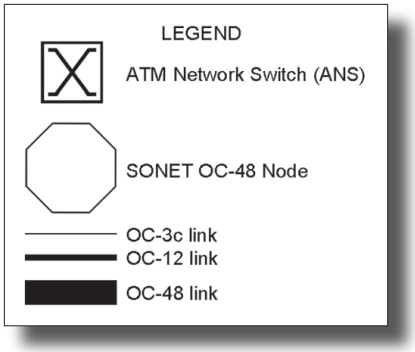
## Staff Credentials

- Electrical Engineering Technicians

## Laboratory Services

- Performance, conformance, and interoperability testing of telecommunications systems equipment and devices
- Network design and analysis
- Custom software development
- Troubleshooting of telecommunications equipment and fiber-optic cabling
- Commercial off-the-shelf (COTS) software integration and implementation with custom designs
- Equipment specification and test plan development
- Telecommunications system specification, design, analysis, testing, and acquisition
- System integration
- Network management and monitoring systems
- Digital video technology over networked systems
- Software development (real-time, embedded, and general-purpose computing)
- Network architectures and protocols (e.g., Voice over Internet Protocol [VoIP], Internet Protocol [IP], Generalized Multiprotocol Label Switching [GMPLS])

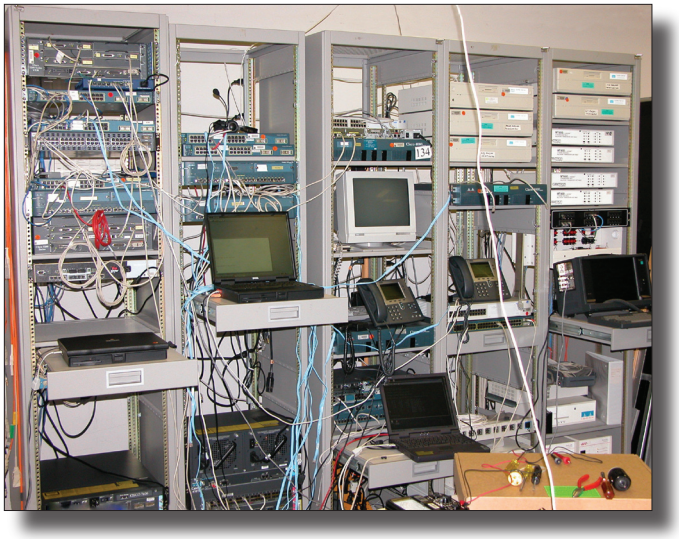



*ATM and SONET Transmission System block diagram*

## *Recent Notable Achievements*

- Responsible for all the design, specification, equipment identification, and acceptance certification for the KSC SONET and ATM transmission systems, which support all the voice, video, and data traffic at KSC.
- Supported the Launch Services Program with system design and vendor equipment testing for the ATM network replacement at KSC and Vandenberg Air Force Base.
- Provided 10 GB Ethernet switch testing for Constellation proof of concept of an Ethernet backbone for launch and control systems.
- Performed a quick redesign and implementation at the KSC gateway network boundary, which allowed KSC to meet its data performance requirements during the launch of STS-95, John Glenn's return to space aboard Discovery. The volume of data traffic experienced in this launch was unprecedented, and the laboratory's redesign efforts provided Internet viewers of the event a positive experience.



*Routing protocols and network standards testing and conformance*

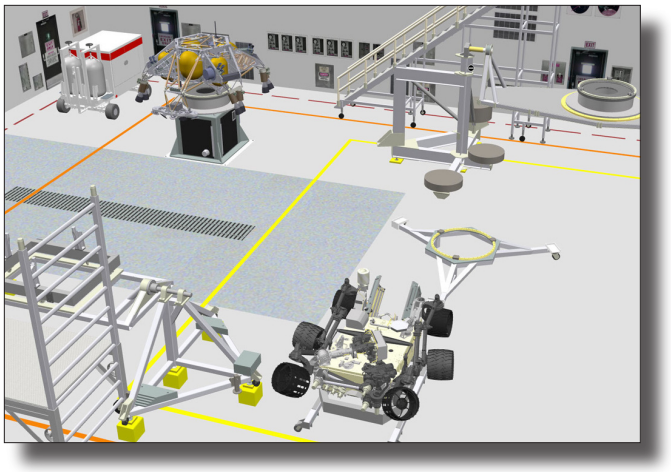
*Laboratory Operator & POCs:*
*NASA – James Shaver, Mail Stop: NE-D1, KSC, FL 32899*
*James.M.Shaver@nasa.gov, (321) 867-9883*

*Contractor – Gregory Nelson*
*Mail Stop: ASRC-18, KSC, FL 32899*
*Gregory.S.Nelson@nasa.gov, (321) 867-6320*

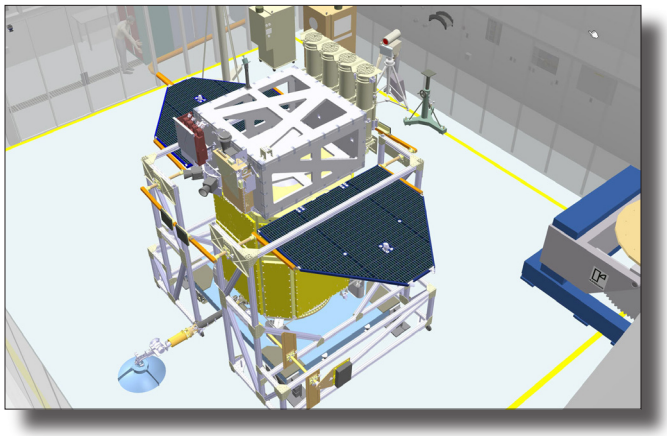
*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# Design Visualization Laboratory

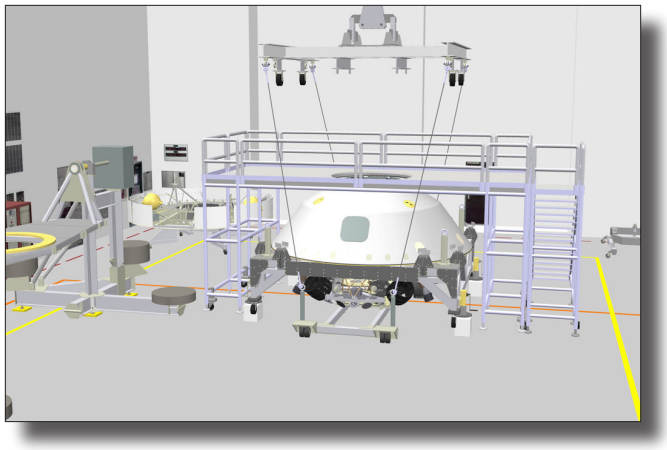
Visualization is the process of taking complex objects and systems and representing them in simpler formats to aid in their understanding and analysis. The Design Visualization Laboratory has developed a variety of visualization products over the years. One of the most common uses of the laboratory capability is that of virtual design review. This entails producing three-dimensional (3D) models and simulations of proposed designs and design changes for our customer organizations. These designs can be reviewed by the design team in the laboratory to determine their suitability early in the design process when it is still easy to change should there be difficulties or interferences. The Design Visualization Laboratory has a strong history of completing projects as expected, on time, and within budget in environments known for program restructures and the resultant effects on schedules and available resources.



*MSL processing nears completion*



*Ground operations processing simulation for the Solar Dynamics Observatory*



*Mars Science Laboratory Ground Operations Processing simulation*

## Laboratory Services

- Reverse engineering via noncontact 3D digitization
- 3D model generation
- Simulation environment development
- Simulation tool development
- Simulation operation
- Simulation infrastructure maintenance (configuration management, database, hardware, software, etc.)
- Conversion of real-time simulation on high-end computer systems to an archived form for playback on desktop computers via the Distributed Observer Network (DON) tool.

## Staff Credentials

- Engineers
- Principal Engineer
- Software Engineers

## Recent Notable Achievements

- Provided extensive support to the Constellation Program in the areas of modeling, simulation, and reverse engineering, including:
  - Laser scanning of the Vehicle Assembly Building highbay to confirm a structural conflict for Ares I-X.
  - Modeling and simulation of many vehicle concepts for the Constellation Program.
  - Numerous ground operations processing simulations of Ares I-X, Ares I, and the Lunar Surface Access Module (LSAM).
- Participated in the development of the DON Delmia Envision simulation export capability, thereby providing some of the first simulation content for the DON system.
- Provided extensive support to the Launch Services Program in the areas of modeling, simulation, and reverse engineering, including:
  - Laser scanning and modeling of various Astrotech facilities and the Payload Hazardous Servicing Facility.
  - Modeling and simulation for the Mars Science Laboratory.
  - Modeling and simulation for the Solar Dynamics Observatory.

## Laboratory Assets & Specialized Equipment

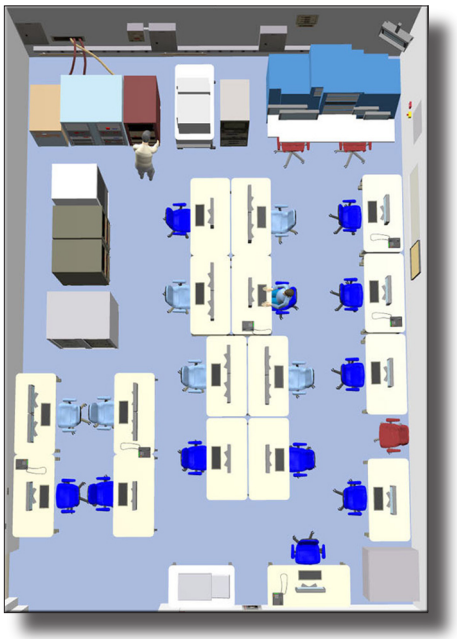
- Trimble long-range and short-range laser scanners and associated software tools
- ATOS visible light scanner and associated software tools
- Photo G Photogrammetry System and associated software tools
- Nonlinear video editing system for capturing and developing video from 3D visualizations produced by the laboratory
- Simulation display room with specialized capability to display real-time simulations to large audiences

*Laboratory Operator & POCs:*
*NASA – Matthew Verdier*
*Mail Stop: IT-C1, KSC, FL 32899*
*Matthew.J.Verdier@nasa.gov, (321) 867-7608*

*Contractor – Bob Humeniuk*
*Mail Stop: 7210-C385, KSC, FL 32899*
*Robert.P.Humeniuk@nasa.gov, (321) 867-2012*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

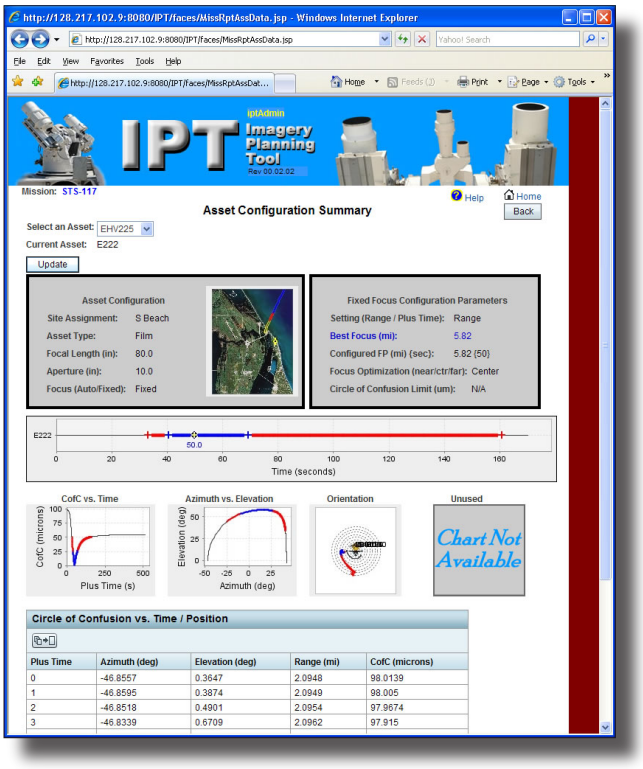
*Ground Operations Processing simulation for the Solar Dynamics Observatory (SDO)*



*Close-up view of the 3D model used in the SDO simulation*

# Experimental Imaging Laboratory

The Experimental Imaging Laboratory explores current and emerging imaging technologies and characterizes camera, lens, recorder, and tracking methods. The lab is a dynamic mixture of field-deployable imaging assets and fixed-location test equipment. Lab engineers perform experiments in a controlled environment and compare performance with a field setting. The lab staff reflects a mixture of expert backgrounds in image analysis, comprehensive data collection, video engineering, and complex system integration to apply imaging capabilities to tracking and network systems. Rapidly evolving, high-speed imaging systems require an extended understanding when attempting to evaluate end-to-end configurations. In addition, recording methods that take advantage of various image compression codecs need to be studied and compared for full-system compatibility and performance. The Experimental Imaging Lab provides a testbed for benchmarking those technologies to what is currently available. This valuable service offers direction on practical and cost-effective choices for imaging hardware of all varieties (high definition, high speed, nonvisible spectrum) and on choosing the most capable methods to deploy these devices and to acquire the best available images for current and future programs.




*Screen-shot of the Imagery Planning Tool (IPT)*

## Laboratory Services

- Test imaging and optics systems, equipment, and devices for performance, conformance, and interoperability
- Analyzes imagery
- Characterize the temperature of events, objects, and debris
- Analyze launch/lift-off debris
- Assess recording devices and codecs
- Assess best methodologies to time-tag, synchronize, and transfer images and large image files
- Develop methods to quickly and easily archive and retrieve volumes of imaging data
- Apply modern acquisition methods to evaluate the performance of tracking systems
- Develop equipment specifications and test plans
- Configure tracking mounts for optimal performance
- Develop theoretical programs to assist imaging and tracker positioning
- Maintain familiarity with emerging imaging technologies and applications
- Collaborate with the imaging community for next-generation imaging sensors
- Maintain expert knowledge of digital video technology and transmission systems
- Use computer tools specifically developed to provide predictive data for best performance of lenses, cameras, and trackers on a launch-by-launch basis

## Recent Notable Achievements

- Developed the Imagery Planning Tool (IPT), a comprehensive program that constructs a mission (launch) profile of imaging resources (trackers, cameras, and lenses) based on all aspects of mission deployment and setup (location, time of day, mission trajectory). The goal is to achieve the best imaging opportunity and quality.
- Support the refurbishment of the 180-inch lenses to improve optical quality and performance and to reduce the weight for easier handling and deployment.
- Study the practicality of synchronization of all tracking cameras to a common time to determine the benefit on image analysis.

- Perform vibration study to understand and minimize vibration and jitter of tracking mounts caused by launch acoustics and internal operation.
- Collaborated with other ranges to develop an atmospheric turbulence study to characterize the effect of the atmosphere on optical performance. Understanding this will help indicate and predict the atmospheric conditions that will affect image quality.
- Continue operational support of all launches, assist with debris analysis, characterize of camera, lens, and tracker performance, evaluate additional imaging methods (infrared, ultraviolet, nonvisible spectrum), and identify nonproprietary data formats that work with common codecs for compression, data transmission, and archiving.
- Developed algorithms that compute lens and camera focus performance
- Conducted analysis to determine resolution limits on measurements of lift-off debris
- Conducted analysis of pointing errors resulting from nonorthogonality and wobble of tracker mount rotation axes

*The EMS tracker control system user interface*

## Staff Credentials

- Video Engineer
- Technician

## Laboratory Assets & Specialized Equipment

- Field-deployable trailer to run field experiments
- Small tracker platform
- Integrating sphere for camera and lens characterization
- LabDITSC to validate and calibrate camera speeds and accuracy
- QuVIS recorders to capture and compress high-definition images for network transfer
- High-speed digital video cameras to understand performance and benchmark to existing technology
- High-definition video generator and test set
- ISO standard resolution charts and filters for camera and lens characterization
- Blackbody source to calibrate infrared sensors
- Course wave division multiplexing system for providing end-to-end network connections
- Multi-image display system
- Long-wave infrared and mid-wave infrared video cameras
- 25 to 600 mm (variety) infrared lenses
- Two JPEG2000 compression suites for remote control of field experiments

*EMS tracker with four infrared cameras and a high-definition camera for night launch experimentation*

*Laboratory Operator & POCs:*
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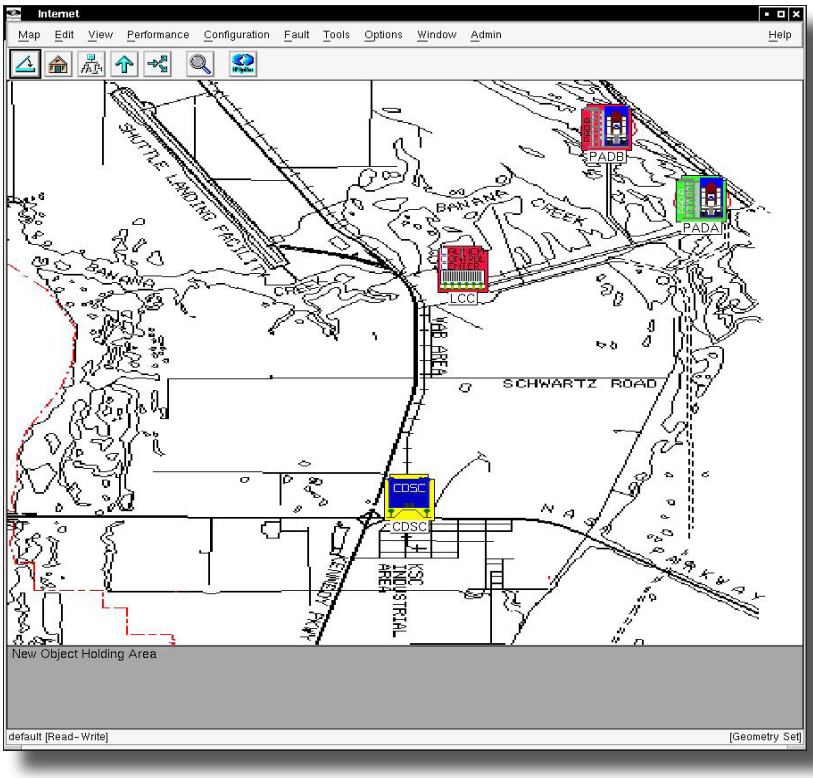
*Contractors – Todd Lamb, Mail Stop: ASRC-18, KSC, FL 32899*
*Todd.A.Lamb@nasa.gov, (321) 867-5795, and*

*Tom Kelly, Mail Stop: ASRC-18, KSC, FL 32899*
*Thomas.J.Kelly-2@nasa.gov, (321) 867-8216*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# Fiber Optics and Communications Laboratory

The Fiber Optics and Communications Laboratory leads the research, analysis, design, development, and deployment of all fiber-optic-based cabling systems used for communications at KSC, including the conversion, integration, and deployment of digital video systems for the KSC Operational Television (OTV) and Broadband Communications Distribution System (BCDS) television systems and nearly every fiber-optic-based cable installed at KSC. The laboratory provides a testbed and technical expertise enabling maximum efficiency from current investment in fiber optics and video systems. The laboratory can support research and analysis in virtually any fiber-optic and video technology, including wavelength division multiplexing techniques, cabling technology, free-space optical systems, and high-definition and other digital video systems. The Fiber Optics and Communications Laboratory has a history of meeting defined schedules and budgets while responding to the dynamics and uncertainties of new technologies.




*Example screen of the patented Remote Monitoring and Alarm System*

## Laboratory Services

- Performance, conformance, and interoperability testing of telecommunications systems equipment and devices
- Fiber-optic cable deployment, termination, and analysis equipment and devices
- Custom software development (real-time, embedded, and general-purpose computing)
- Troubleshooting of telecommunications equipment and fiber-optic cabling
- Commercial off-the-shelf (COTS) software integration and implementation with custom designs
- Equipment specification and test plan development
- Telecommunications system specification, design, analysis, testing, and acquisition
- System integration
- Network management and monitoring systems
- Digital video technology and fiber-optic transmission systems

*Related fiber-optic projects, including add-drop mux, wideband video systems research, and video test rack*

## Recent Notable Achievements

- Designed and developed a fiber-optic-based communications infrastructure for the KSC Launch Equipment Test Facility (LETF). The system provides 144 single-mode fibers and Ethernet service in hazardous operation test areas. The design includes the implementation of a private local area network infrastructure for LETF test system control.

- Designed and developed a new video system for the LETF. The system provides 10 remotely operated cameras located at various hazardous testing locations around the LETF. All of the video transmitted into the redesigned LETF Control Room is used to monitor and record LETF test operations.

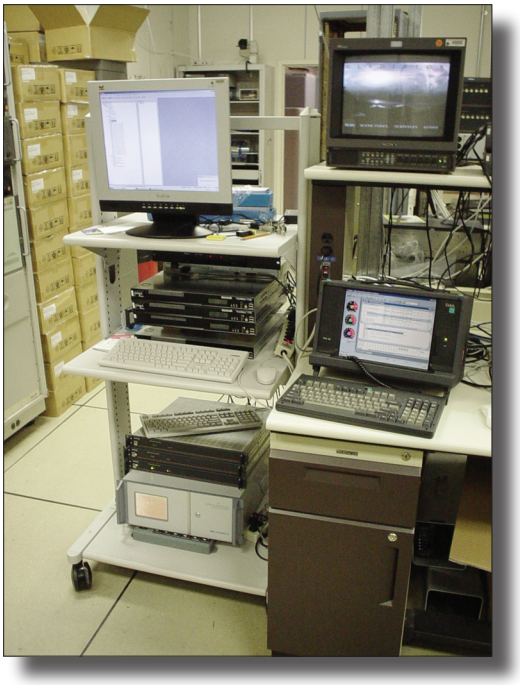
- Designed and implemented a digital upgrade on the BCDS. Design provided digital video (including high definition) and data services on the existing analog cable television infrastructure, increasing the potential channel count of the system from 46 to 368.

- Performed the system design, development, implementation strategy, and qualification testing for KSC's new Digital Video Transmission System (DVTS). The system represents an upgrade to KSC's existing analog Wideband Transmission System – Fiber (WBTS-F). DVTS provides digital video and data services over a Course Wavelength Division Multiplexed network of single-mode fibers.

- Performed troubleshooting and discovered a serious fiber-optic cable failure mode in a key link providing communications between the Launch Control Center and the Shuttle launch pads. Resolution of this failure mode involved significantly modifying all future specifications used for fiber-optic cabling systems at KSC.

## Staff Credentials

- Electrical Engineers
- Network Engineers
- Technicians



*Test rack for the DVTS*

## Laboratory Assets & Specialized Equipment

- 3 GB lightwave component analyzer
- 20 GB digital sampling oscilloscope and two general-purpose oscilloscopes
- Spectrum analyzers and optical spectrum analyzers
- Waveform function generators
- Optical time-domain reflectometers
- Optical wavelength meters and power meters
- Erbium-doped fiber amplifiers and variable optical attenuators
- Video generator platforms
- Optical fiber fusion splicer
- VM700 video test sets
- Video waveform monitors
- Video compression quality analysis

*Laboratory Operator & POCs:*
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*Contractor – Robert Swindle, Mail Stop: ASRC-29, KSC, FL 32899*
*Robert.W.Swindle@nasa.gov, (321) 867-6942*

*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# IT System Services Laboratory

The IT System Services (ITSS) Laboratory provides institutional networking and communications support for the Engineering Development Laboratory (EDL) (Building M7-409). This includes IP address assignments for any workstations attached to the ITSS Lab network. In addition, it provides support for video circuit connections from the cable service taps throughout the building. Support is provided to the network border (service face plate) in all offices and labs (but not for the internal needs of the offices and labs). IT and audio/video systems infrastructure maintenance and support are provided for the EDL Conference Rooms 1023 and 2106.

*IT System Services Lab test rack, new equipment, and configuration testing is performed here*

## Laboratory Services

- Monitor network traffic loads and trends using the "What's Up Gold" monitoring software and the open-source software "Multi Router Traffic Grapher" (MRTG).
- Troubleshoot data flow problems between the boarder router and clients when they arise. We also troubleshoot client-related security problems on the network.
- Maintain network topology diagrams for the cable plant and room layouts, including network drop locations.
- Provide network design, cable installation, troubleshooting, and maintenance to IEEE cable standards using a network cable certifier. The cable certifier performs standard and extended 4-pair tests such as pin-out, continuity, speed, data packet, length, and crosstalk.

## Laboratory Assets & Specialized Equipment

### Network & Protocol Analysis

- DOLCH PAC 64
- DOLCH PAC 65
- Wandel & Golterman DL 30

### Network Certification

- Test-Um NT955 Validator
- Microtest Pentascanner

### Network Statistics & Monitoring Software

- What's Up Gold Professional V.11
- MRTG – Multi Router Traffic Grapher (open-source)


*What's Up Gold Monitoring Station – Tracks network use statistics and device status, and stores device logs*

## Recent Notable Achievements

- Successfully installed and configured a new Cisco 2821 router for the Data Acquisitions Labs (DAS) and weather labs. Linked the two labs by routing dedicated cabling.
- Successfully installed and configured a new 3845 router in the Advanced Network Develop Lab.
- Successfully installed a Cisco 3750G-12S switch. This switch is a primary component of the EDL network backbone.
- Facilitated the installation of wireless access points to extend service to the second floor of the EDL.
- Successfully installed and certified a new cable plant to extend networks and phone service to four new trailers placed outside of the EDL. The job required over 200 Customer Face Plates (CFPs). The building numbers are TR6-0117, TR6-0118, TR6-0119, and TR6-0120.

## Staff Credentials

- IT Systems Engineers
- Computer Engineers
- Technicians

*Laboratory Operator & POCs:*
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*Jim Grooms*
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*Location:*
*Engineering Development Laboratory (Bldg. M7-409)*

# Spaceport Processing Systems Development Laboratory

The Spaceport Processing Systems Development Laboratory (SPSDL) is a multifunctional laboratory (testbed) available for designing, developing, prototyping, analyzing, testing, certifying, and implementing hardware, software, and related technologies for small- to medium-sized computer control systems. Several different hardware platforms, computer operating systems, development tools, and work control systems may be loaded on the laboratory equipment, thereby providing various build options for customers. Efforts focus on providing flexible, innovative solutions to our customers' and partners' needs in the areas of command, control, monitoring, and range systems. Laboratory personnel and software developers are technically capable in multiple disciplines and are constantly investigating new computer technology. SPSDL can accommodate up to 30 people engaged in display, implementation, and testing activities. The laboratory can be used as a single large-development environment or can be divided into smaller test sets to simultaneously service multiple customers as requirements warrant.

## Laboratory Services

- Requirements analysis/technology evaluation/ trade study
- Computer hardware and software engineering support
- Configuration management planning services
- Testing and verification support
- Simulation and process improvement
- Command/control system development and sustaining engineering
- Rapid prototyping of advanced command and control concepts
- Information support
  - Database services
  - Web application services
  - Data monitoring, distribution, recording, and retrieval
  - Advisory/expert system development

## Laboratory Assets & Specialized Equipment

- Object-oriented analysis/design
- Telemetry acquisition/processing
- Database development (Access, PostgreSQL, Oracle, etc.)
- Real-time operating systems (RTOS) development (Linux, VxWorks, Unix, etc.)
- High-level-language programming (C++, JAVA, C, XML, etc.)
- PC application development (Windows, Linux, etc.)
- Unix application development
- Command and control technology evaluation (LabVIEW, GLG, GTK/GNOME, etc.)
- Web application development (PHP, ColdFusion, JAVA, etc.)
- Embedded JAVA development
- Object Linking and Embedding (OLE) process control development
- Agent-based application development (JAVA Expert System Shell, JAVA Development Kit, Swing, National Oceanic and Atmospheric Administration's Software Graphics Toolkit, Eclipse, JUnit, and Ant)
- 22 servers

## Staff Credentials

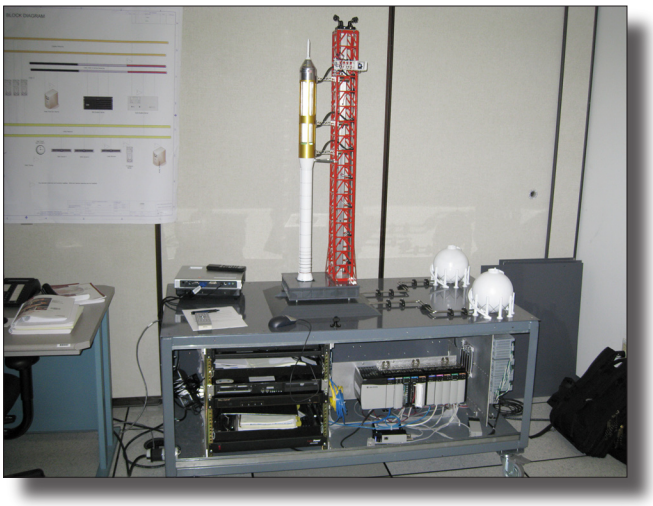
- Computer Engineers
- Software Engineers
- Network Engineers
- System Administrators

## *Recent Notable Achievements*

- Supported Constellation Program Command Control and Communications Project Launch Control System (LCS) proof of concept. The proof-of-concept effort was chartered by Constellation to address key technical aspects of the architecture, including fault tolerance, redundancy management, data distribution and closed-loop performance, telemetry and command processing functionality, software layering/isolation, distribution and allocation of control, and the use of scripting languages for application development. SPSDL resources were used to augment LCS resources to support the proof-of-concept effort.

- Developing several agent-based applications, including the NASA Engineering Shuttle Telemetry Agent (NESTA) and the Launch Commit Criteria Monitoring Agent (LCCMA). NESTA provides autonomous monitoring of the Shuttle data stream and automatically alerts, via e-mail or pager messages, NASA engineers when predefined criteria have been met. Monitoring criteria can be defined as expected operational events or milestones and as unexpected events or failures. The end user creates a rules file that contains data monitoring requests. LCCMA monitors the Shuttle data stream for launch commit criteria violations and warnings. For this application, the rules file contains limits for each violation or warning specified. The rules file is parsed at application start-up, and a data stream for monitoring is also selected.

- Research is under way to extend the agent-based applications with truth maintenance systems (TMSs). The objectives are to provide advanced diagnostics and prognostics for Shuttle ground subsystems and to extend these technologies for the Exploration Initiative.



*Laboratory Operator & POC:*
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*Lynn.R.Svedin@nasa.gov, (321) 867-2970*

*Location:*
*Space Station Processing Facility (Bldg. M7-0360)*

# Telescience and Internet Systems Laboratory

The Telescience and Internet Systems Laboratory develops and implements technologies that securely extend KSC's payload processing, launch processing, engineering, and research capabilities to remote locations using Internet protocols. The laboratory stays on the leading edge of technologies that packetize and route voice, video, telemetry, and data services over computer networks.

The Telescience and Internet Systems Laboratory has the expertise and infrastructure needed to develop and deploy applications that can stream video, audio, telemetry, and high-resolution computer desktop screens through multiple networks and regenerate them at remote locations. This includes expertise in Virtual Private Networks (VPNs), wireless technologies, Voice over Internet Protocol (VoIP), video over IP, open-source software, database systems, streaming telemetry, data acquisition over IP, and computer/network security.

*The laboratory developed the technology required for Space Station experimenters offsite of KSC to securely access voice, video, and data systems undergoing checkout testing in the Space Station Processing Facility. This capability provides a cost savings by increasing the flexibility of checkout test schedules and reducing travel requirements.*

## Laboratory Assets & Specialized Equipment

- Voice/Video/Data Distribution – Infrastructure for the streaming distribution of voice, video, and telemetry using Internet protocols
- Point-to-Point Microwave Link Equipment – Delivers high-speed network access to remote test locations
- Virtual Private Network Equipment – Securely extends KSC's network architecture to remote locations
- Eight-Node Linux Cluster – Distributes near-real-time data using Internet protocols
- Remote Networking Relay Vehicle – Provides satellite uplink/downlink capability to remote test locations
- IP Camera Systems – Provides remote pan/tilt/zoom control with image stabilization for outdoor use
- Remote Operations Command Trailer – 53 ft command trailer with network infrastructure
- Remote Operations Vehicle – Custom command vehicle providing voice, video and data operational support
- Satellite Dish – Portable uplink/downlink satellite dish with trailer

## Laboratory Services

- Data services: storage, transport, and backup for special project requirements
- Computational services
- Streaming video/audio/data
- Internet camera monitoring and control
- Data transfer conversion support
- Secure and anonymous file transfer protocol (FTP) sites
- Technical mailing lists
- Mobile Internet connectivity
- Inter-Center data mirroring
- Software engineering and computer programming
- Software development using PERL, C, Java, Python, PHP, and open-source systems
- Network routing, high-speed switching, and network analysis
- Application/Layer-4 switching, data mirroring, and secure data transfers
- High-bandwidth and high-availability Web and data services
- Distributed computing
- Voice and video over IP, H.323 teleconferencing
- Network design, fabrication, and testing
- Expertise in wireless and satellite-based IP
- Internet camera monitoring and control

## *Recent Notable Achievements*

- Designed, built, and currently operate a streaming video/audio system for Payload and Launch Services to provide mission launch support. This custom-designed, Java-based, Layer-4 clustered I/O engine streams real-time telemetry over the Internet using the UDP protocol. The system provides an Internet-based count-down clock with 1- to 2-second accuracy for the launch of Expendable Launch Vehicles (ELVs). ELV launches from the East and West Coasts of the United States are supported.

- Designed, built, and installed a mission streaming audio/video system for Space Station Utilization Payloads (Settebello-II).

- Designed, built, and operate a prototype system to stream four Space Station flight VGA laptop displays at full resolution to remote locations among payload customers and multiple NASA Centers. Set up VPNs to extend the Space Station Network to remote locations for integrated testing.

- Supported scientific Webcasts for joint projects between NASA and the National Oceanic and Atmospheric Administration, Corrosion Technology Laboratory, Cryogenics Test Laboratory, Robotics Competitions, and Biomedical Chambers.

- Designed, built, and currently operate a mobile hard-line, satellite, and point-to-point microwave computer network infrastructure that can extend the network capabilities of (voice, video, data) of any NASA Center to remote locations. In September 2007, the lab used this capability to provide communications for simulated lunar surface spacesuit and rover operations in a volcanic cinder field in Arizona.

## *Staff Credentials*

- Aerospace Engineer
- Chemical Engineer
- Computer Engineer
- Electrical Engineer
- Software Engineer

*The laboratory supported the Goddard Space Flight Center Operating Missions as Nodes on the Internet Project in providing live streaming video and telemetry of the total eclipse of the Sun from the Black Sea via NASA Tracking and Data Relay Satellite System downlink.*

*In September 2007, the laboratory deployed a point-to-point microwave computer network infrastructure providing secure communications in support of simulated lunar surface spacesuit and rover operations in a volcanic cinder field in Arizona. This system provided network-based voice, video, and data communications back to NASA Centers participating in the field test.*

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*Location:*
*Operations and Checkout Bldg. (M7-355)*

# *Life Science Laboratories*

# Analytical Chemistry Core Laboratory

The Analytical Chemistry Core Laboratory resides in three rooms of the Space Life Sciences Lab (SLSL) and occupies a total of 2,000 $ft^2$ of floor space. It is equipped with a full spectrum of state-of-the-art analytical instruments for both qualitative and quantitative analyses of nonvolatile organics, volatile organics, elements, and ions to meet diverse operational and research needs. The lab has three primary missions: (1) Service: Provide technical expertise and maintenance of analytical systems; (2) Technology Development: Develop instrumental applications, metabolomics, and small sensors; and (3) Research: Conduct and promote cross-disciplinary collaborative research.


*Christie Ledeker, a summer intern from the University of Delaware, performs an analysis of antioxidant capacity of vegetable extracts using the GENios Pro multidetection microplate reader from TECAN.*

## Laboratory Services

- Train students, technicians, and researchers on the operation of advanced instruments
- Provide consultations on the application of advanced analytical techniques to solve specific questions
- Coordinate the use of laboratory resources
- See <*http://www.lssc.nasa.gov/als/chemistry/*> for more information

## Laboratory Assets & Specialized Equipment

- Element and ion analysis
  - Inductively coupled plasma – optical emission spectrometer (ICP-OES)
  - Total organic carbon (TOC)/total nitrogen (TN) analyzer
  - Carbon, hydrogen, nitrogen, sulphur, and oxygen (CHNS-O) elemental analyzer
  - Ion chromatograph (IC)/suppressed conductivity
- Targeted organic compound analysis
  - Gas chromatograph (GC)/ flame ionization detector (FID)/ thermal conductivity detector (TCD)
  - High-performance liquid chromatograph (HPLC)/ diode array detector and evaporative light scattering detector
  - HPLC/pulsed amperometric detector
- Metabolite profiling and structural elucidation
  - Gas Chromatograph/Mass Spectrometer (GC/MS)
  - HPLC/Ion Trap Mass Spectrometer
- Biochemistry work and sample preparation for instrumental analysis
  - Ultraviolet-visible spectrometer
  - Multidetection microplate reader
  - High-speed solvent evaporator (Cyclone)
  - Microwave digest oven and block digest
  - Microbial volatile organic compound collection chambers
  - Other essentials (rotary evaporator, thermomixer, centrifuge, water batch, sonicator, etc.)

## Staff Credentials

- Chemists
- Plant Biologists

## *Recent Notable Achievements*

- Acquired a multidetection microplate reader (GENios Pro): The automated dichroic-based microplate reader is tailored to measure absorbance, fluorescence intensity, time-resolved fluorescence, dual-emission fluorescence, and luminescence. The instrument offers heated incubation and shaking, and accommodates plate formats from 6 to 384 wells in all detection modes. Furthermore, it includes dual injectors for automated reagent addition.

- Developed metabolite profiling capability to enable simultaneous detection of a large number of compounds by the coupling of powerful GC/MS technology and advanced mathematic algorithms.

- Supported the development of bioreactors for waste water treatment and facilitated the process for obtaining extramural grants.

- Continued to support the development of solid waste management, air revitalization, and potable water preservation strategies.

- Received American Society of Horticultural Science Outstanding Ornamentals publication award in 2005 for the paper "Seed Storage Reserves and Glucosinolates in *Brassica rapa L*. Grown on the International Space Station," by M. E. Musgrave, A. Kuang, L. K. Tuominen, L. H. Levine, and R. C. Morrow. The document was published in 2005 in the *Journal of the American Society of Horticultural Science*, issue 130(6).

- Secured two Center Director's Discretionary Fund projects: "Metabolomics" and "RT-MATRIX." RT-MATRIX aims to develop a real-time, low-power, small, autonomous sensor for simultaneous determination of the total level of organic contaminants and identification of contaminant constituents.

*Will Rigdon (a Dynamac chemist) is evaluating the efficiency of a prototype photocatalytic oxidation cell to be incorporated into the RT-MATRIX.*

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*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Applied Genetics Technology Core

The Applied Genetics Technology Core (AGTC) is engaged in research and advanced technology development for the detection, enumeration, identification, monitoring, and control of microorganisms and microbial processes in spacecraft environments, engineered systems for human exploration, and natural ecosystems. The Core is composed of five laboratories equipped with state-of-the-art analytical instrumentation for DNA sequencing, bacterial enumeration, biological imaging, microbial identification, molecular biology, and sustainable systems engineering. The AGTC applies the tools of molecular biology, microbiology, genetics, biochemistry, and biological engineering to assess the microbial ecology of spacecraft environmental control and life support systems and engineered systems for air, water, and solid waste processing. AGTC projects include advanced microbial monitoring and control for spacecraft potable water systems, bioreactor design for water recovery and wastewater treatment, and microbiological monitoring of spacecraft solid waste management systems.

## Laboratory Assets & Specialized Equipment

- Agilent Bioanalyzer 2100 Lab-on-a-Chip System
- Alpha Innotech FluorChem 8900 Gel Imaging System
- Applied Biosystems ABI 3130 Genetic Analyzer for DNA sequencing
- Applied Biosystems ABI 7700 Genetic Detection System for real-time quantitative polymeraise chain reaction (QPCR)

- Biolog OmniLog Phenotype Microarray (PMA) and Microbial Identification (MID) System
- Biotek Synergy HTTR Microplate Reader
- Dynex MRX and Revelation Microplate Readers
- Hybaid Express and MJ Research PTC-200 Polymeraise Chain Reaction (PCR) Thermocyclers
- Molecular Imaging PicoPlus Scanning Probe Microscope
- Olympus IX71 and IX81 Inverted Research Microscopes
- Olympus SZX12 Stereo Zoom Microscope
- PerkinElmer VICTOR2 Microplate Reader
- PerkinElmer UltraVIEW ERS 3E Confocal Microscope with 3-line laser and Olympus IX81 Motorized Inverted Microscope
- Roche LightCycler 480 System for real-time QPCR
- Zeiss Axioskop2 Research Microscope with Olympus DP71 Digital Camera and Image-Pro Software
- High-speed analytical centrifuges, incubators, biological safety cabinets, and refrigerators/freezers for controlled-sample and reagent storage

## Laboratory Services

### Biomolecular Lab

- DNA/RNA extraction and purification from environmental, clinical, and tissue samples.
- Nucleic acid quantification, sequencing, and fragment analysis for gene identification, bacterial and fungal identification, microbial strain typing, and community-level phenotypic profiling.
- PCR amplification of DNA and RNA.

- Real-time QPCR for gene detection, gene quantification, gene scanning, and cell genotyping to identify, track, and quantify pathogens.
- Microplate spectrophotometry for quantification of cellular chemistry, enzyme kinetics, and community-level physiological profiling of cells by absorbance, fluorometry, and luminometry.
- Image capture and analysis of electrophoresis gels, nucleic acid hybridization, and macroarray detection formats for the quantification of nucleic acids, proteins, and cells.

### *Microbial Ecology Lab*

- Enumeration of bacteria and fungi recovered by cell cultivation using selective media.
- Enumeration and identification of total, active, viable, and nonviable bacteria and fungi by immuno-fluorescent staining and microscopic direct count.
- Receipt, handling, storage, analysis, and evaluation of biological agents, including infectious microorganisms of moderate risk classified as Biological Safety Level 2.

### *Sustainable Systems Engineering Lab*

- Design, testing, and operation of advanced biological reactors and control systems for bioregenerative water recovery for space and terrestrial applications.

### *Bioimaging Lab*

- Laser confocal microscopy and image analysis.
- Scanning probe microscopy/atomic force microscopy.
- Transmitted-light brightfield, darkfield, phase contrast, differential interference contrast, and epi-fluorescence microscopy of materials and fixed or living biological samples.

### *Aseptic Operations Lab*

- Class 100, positive pressure, controlled work area (15' × 10') with HEPA air filtration, germicidal UV-C lamps, and a laminar-flow clean work bench for aseptic operations, including cell tissue culture and spaceflight hardware assembly, processing, and de-integration.

## *Staff Credentials*

- Molecular Biologist
- Microbiologist

## *Recent Notable Achievements*

- Supported the NASA Exploration Systems Mission Directorate (ESMD) Exploration Life Support (ELS) Program to evaluate environmental control and life support (ECLS) technologies for the Constellation Program.
  - ELS Water Recovery Systems – Completed studies to determine the efficacy of advanced microbial control technologies for spacecraft potable water and ECLS systems.
  - ELS Waste Management Systems – Completed studies to assess risks to crew health and maintain planetary protection requirements by mitigating the effects of microbiological growth and volatile organic compound production in waste management systems for spacecraft and surface habitats.
- Developed biological-payload flight hardware and completed flight experiments on Shuttle and International Space Station (ISS) to quantify the effects of growth in microgravity on the rates of genetic recombination and evolution in bacteria. The experiment, Passive Observatories for Experimental Microbial System, flew on STS-121 and ISS increments 13 and 14.
- Completed ground testing of Forward Osmosis Bag technology for the NASA Exploration Technologies Development Program to determine the feasibility of using a commercial off-the-shelf water treatment device for contingency recovery of potable liquid from human urine to support Orion flight, landing, and recovery mission operations. Testing validated that the membrane can remove 99.9999% of a bacterial population from raw water and reduce the concentration of many environmental contaminants.
- Collaborated on a study by the U.S. Department of Agriculture to optimize and validate a high-throughput Oxygen Biosensor System developed at KSC for community-level physiological profiling of bacterial communities in complex environmental matrices. This work was published in peer-reviewed scientific publications.
- Collaborated on a study with the Cooperative Institute for Coastal and Estuarine Environmental Technology at the University of New Hampshire and supported by the National Oceanic and Atmospheric Administration to design, build, and test a Redox Control Bioreactor for enhanced nitrogen removal from septic tank effluent. This work was published in multiple peer-reviewed scientific publications.
- Collaborated on a study with the Center for Environmental Biotechnology at the University of Tennessee to validate a two-component, bacteriophage-based, bioluminescent reporter system for the direct detection of *Escherichia Coli* in environmental matrices. This study was published in peer-reviewed scientific publications.

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*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Bio-Medical Laboratory

The Bio-Medical Laboratory is fully equipped to conduct research and field testing on a wide variety of manned systems. Among this laboratory's capabilities are testing advanced forms of personal protective equipment, biometric signal acquisition and analysis, and physiological and metabolic testing and analysis. Further, the laboratory can design, test, and fabricate the systems and equipment related to these capabilities. Specialties in the manufacture, maintenance, and testing of cryogenic breathing systems and whole-body protective suits are unique to this laboratory.

Engineering and technical support is also provided to operations customers in the design, fabrication, testing, and operation of emergency medical equipment. This includes emergency radio frequency (RF) communications and triage site electronic data exchange systems directly supporting astronaut rescue at KSC and transatlantic landing sites. Platforms include NASA and Department of Defense helicopters, ambulances, and M-113 armored personnel carriers. Pre- and postflight support of medically related detailed supplementary objectives for flight crew are also provided.

*Medevac equipment in Blackhawk helicopter*

## Laboratory Services

- Design, fabrication, and testing of personal protective equipment and breathing apparatus prototypes
- Design and fabrication of emergency medical equipment and communications devices
- Physiological stress and metabolic testing and analysis
- Physiological and metabolic data acquisition and analysis
  - LabVIEW development system with data acquisition capabilities
  - IOtech data acquisition
  - MATLAB mathematical analysis software with signal processing toolkit
- Tool design and fabrication
  - AutoCAD drafting software
  - VectorWorks drafting and drawing tool software
  - Protel schematic capture and printed circuit board layout software
- Related consultant expertise available
- Design, layout, and fabrication of analog and digital circuitry
- Application and use of bio-medical instrumentation for the acquisition and analysis of physiological signals
- Research of the physiology and metabolic rate of aerospace workers using self-contained atmospheric protective ensemble (SCAPE) and self-contained breathing apparatus (SCBA) and operation of cryogenic SCBA and specialized personal protective equipment
- Maintenance, calibration, and repair of bio-medical instrumentation

## Recent Notable Achievements

- Tested the Impedance Threshold Valve, a device to restore the blood pressure of astronauts on prolonged space flights, designed in part to help ease the unpleasant physical symptoms caused by coronary readjustments that astronauts experience upon return to Earth. The tests monitored how changing valves/flow restrictions altered blood pressure determined from blood flow rates, which were indirectly measured via skin impedance monitors taped to the subject in key areas, and gave greater insight to possible solutions. A spinoff of this idea may surface in cardiac care to help those suffering low blood pressure caused by illness or trauma.

- Developed and tested the Supercritical SCBA. By applying the phenomenon of supercritical air – air brought to nearly cryogenic temperatures under high pressure and changing the state of the air from gas to liquid to supercritical gas – the air pack delivers the large air supply that liquid air packs provide and can be rotated and used in any position like gaseous air packs. This development has the potential of helping safety and rescue personnel operate longer and more effectively in hostile environments, possibly saving more lives.

- Assessed two cooling strategies for the prevention of heat stress in the propellant handler's ensemble. This was a test of both the propellant handler's ensemble and the use of a self-contained liquid air-powered environmental control unit to provide cooling via an air distribution manifold. As part of a project to develop a next-generation Advanced Protective Suit, two cooling methods were compared, one using a cooling vest and the other proposed method of simply directing cool air across the thorax. Results were reported at the conference of the Aerospace Medical Association.

## Staff Credentials

- Bio-Medical Principal Investigator
- Bio-Medical Engineers
- Bio-Medical Technicians
- Physiologists
- Medical Doctors
- Nurses

## Laboratory Assets & Specialized Equipment

- Quick Circuit 7000 Computer Numeric Control (CNC) Mill
- Beckman Metabolic Measurement Chart
- Quinton Stress Test Monitor/Controller
- Konigsberg Telemetry System
- Aerospace Design and Development, Inc. Supercritical Air Mobility Pack Loading System
- Biosystem Posicheck 3 SCBA Test System
- Rosemont NGA 2000 Gas Analyzer
- Normocap Respiratory Gas Analyzer

*Supercritical air pack with liquid-cooled garment*

*Testing of propellant handler's ensembles*

*Laboratory Operator & POC:*
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*Donald.F.Doerr@nasa.gov, (321) 867-6387*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Clinical Laboratory

The Clinical Laboratory supports Space Shuttle and International Space Station missions by assisting in performing crew physicals, family physicals, and clinical laboratory testing and in processing samples (pre- and postflight). Personnel process samples to send back to Johnson Space Center (JSC) at landing and assist principal investigators (PIs) with experiments and using laboratory space and equipment. The laboratory also supports the Occupational Health Facility in clinical microbiology, primary crew contact physicals, and animal handlers' physicals. This involves performing throat, stool, and wound cultures and ova and parasite exams.


*Point of Care Testing (POCT is diagnostic testing at or near the patient care site) is accomplished through the use of a transportable, portable, and handheld instrument, such as the Abbott I-Stat POCT analyzer.*

## Laboratory Services

- Clinical laboratory testing in chemistry, hematology, microbiology, parasitology, and urinalysis
- Other testing, such as RIA, special chemistry, or basic toxicology


*NUAIRE Class II Biological Safety Cabinet*

## Laboratory Assets & Specialized Equipment

- Orchard Harvest Laboratory Information System (LIS) Software
- Beckman Coulter Synchron CX5 Chemistry Analyzer
- Beckman Coulter LH 500 Hematology Analyzer
- VITEK 2 Microbiology Bacterial Identification and Antibiotic Susceptibility Testing System
- Clinitek 100 Urinalysis Instrument
- Two Zeiss Microscopes with 10, 25, 40, 100, and phase-40 objectives (calibrated micrometer)
- Two tabletop centrifuges
- 5 incubators (2 are $CO_2$ and 3 are aerobic)
- Perkin Elmer Lambda 3 UV/Vis Spectrophotometer
- NUAIRE Class II Biological Safety Cabinet
- LABCONCO Fume Hood
- Fisher Isotemp Heat-and-Stir Plate
- Anaerobe jars
- Abbott i-STAT Point of Care Testing, Chemistry/Blood Gas Analyzer
- Packard Crystal Plus Multidetector Radioimmunoassay (RIA) System
- 3 refrigerators (2 °C to 8 °C), 1 freezer (–25 °C to –35 °C), and 1 ultralow freezer (–70 °C)
- Denver L203 Scale (0.001 g to 210 g)
- Denver TL-203 Scale (0.001 g to 210 g)

## *Recent Notable Achievements*

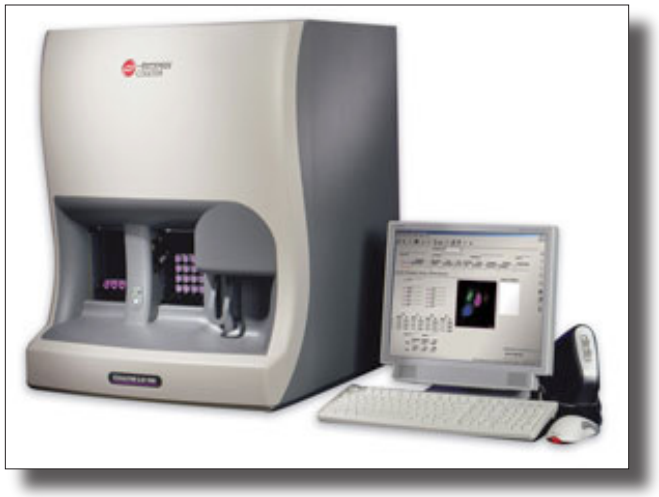
- Continuous accreditation by the College of American Pathologists by meeting the checklist standards for operation of a clinical laboratory and achieving success with all proficiency samples.

- Conversion of our manual system of record keeping into an electronic, paperless system. This was accomplished by acquiring and implementing an electronic LIS. The LIS is a software program that exchanges data about patients, test requests, and test results. The LIS improves efficiency and simplified the laboratory workflow. It also keeps track of individual patients or specimen histories and helps improve the quality of results by reducing errors.

- Ongoing clinical laboratory support for Space Shuttle launches and landings, including performing chemistry, hematology, microbiology, and urinalysis testing on flight crews.

- Support to PIs for Detailed Supplemental Objective work (pre- and postflight): collect blood and urine samples from crew and process, analyze, and/or prepare for shipment to JSC.

- Quality improvement and assurance initiatives that have streamlined and improved numerous laboratory procedures.



*The Beckman Coulter LH 500 is an automated hematology instrument utilizing electric current, impedance, and laser light to perform complete blood counts with white cell differentials*

*The VITEK 2 Microbiology Identification System uses biochemical testing to identify bacteria species and detects growth (as turbidity) to calculate antibiotic resistance and susceptibility*

## *Staff Credentials*

- Pathologist

- Medical Technologists

*Laboratory Operator & POCs:*
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*Contractor – Dr. Arthur Arnold*
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*Arthur.A.Arnold@nasa.gov, (321) 867-2920*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Controlled Environment Laboratory

The Controlled Environment Laboratory (CEL) consists of a state-of-the-art controlled environment chamber (CEC) facility and associated laboratories to conduct basic and applied research with emphasis on the support of both ground and space applications. Controlled environmental parameters include air temperature, relative humidity (RH), spectral quality and quantity, and carbon dioxide ($CO_2$) concentration, and are readily modified to support a wide range of user-defined environmental control requirements. A Low Pressure Testbed (LPTB) capability was recently added and provides a unique chamber to study hypobaric conditions. In addition, the laboratory maintains the technical expertise to facilitate research requiring the use of CECs. The laboratory also develops and maintains a centralized Command, Monitoring, and Data System (CMDS) with an associated database that has the capability to send an alarm when the instruments go beyond the specified ranges. CEC calibration and maintenance are provided, as well as orientation and training for researchers. The CEL is used to support the requirements of a variety of scientific research areas, including NASA, private industry, and academia.

## Laboratory Services

- Controlled environment experiment design, setup, and maintenance
- Physical, chemical, and biological measurements (volatile organic compounds [VOCs], photosynthesis, etc.)
- Materials processing (drying, grinding, freeze-drying, etc.)
- Spectral quality research (light-emitting diodes [LEDs], high-intensity discharge, fluorescent, concentrated solar light)
- Environmental measurements (ultra-low RH, photosynthetic photon flux, spectral quality, hypobaric, etc.)
- Computer control, monitoring, and alarming of chambers and experiments (OPTO-22, CMDS, etc.)

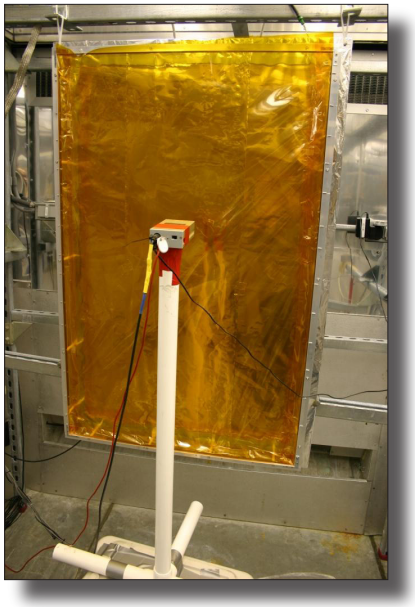
*The Controlled Environment Laboratory has over 600 ft² of controlled environment space, which provides unique control and monitoring of air temperature, RH, light quantity and quality, and atmospheric $CO_2$ and VOC concentrations.*

## Laboratory Assets & Specialized Equipment

- Four 48 ft² walk-in chambers with dual high-pressure sodium (HPS)/fluorescent lamp canopy
- Two 12 ft² reach-in chambers with dual HPS/fluorescent lamp canopy and feedback lamp dimming control
- Two 12 ft² reach-in chambers with fluorescent lamp canopy and moveable shelves
- Two 48 ft² walk-in chambers with fluorescent lamp canopy, vestibule, and ultra-low RH control
- Four 36 ft² walk-in chambers with dimmable fluorescent lamp canopy and vestibule
- Two 15 ft² reach-in chambers with moveable fluorescent lamp canopy
- One 8 ft² reach-in chamber with easily modifiable lamp canopy
- One LPTB hypobaric chamber, 5 kPa to 101 range

## *Recent Notable Achievements*

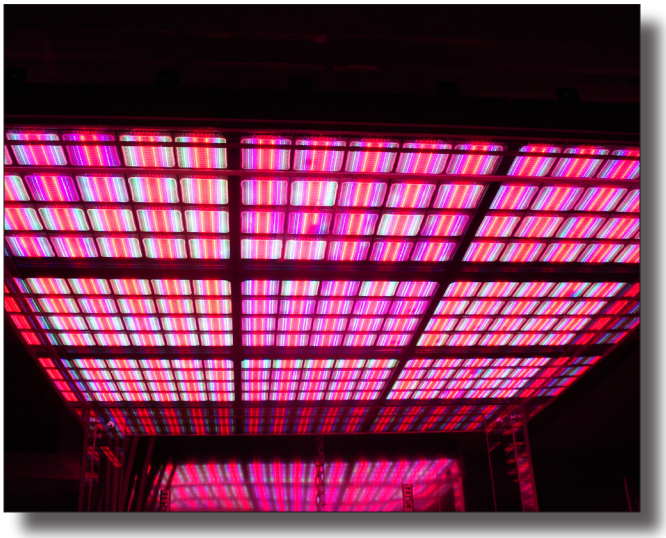
- Support biological research science verification tests and payload verification tests for both Shuttle and International Space Station (ISS) missions.
- Create and maintain specific environmental conditions to test materials to be used as protection against corrosion.
- Implementation of a Space Act Agreement to grow genetically modified soybean plants and evaluate their growth and yield characteristics for use as part of the planned future bioregenerative life support systems on long-duration space missions.
- Support of long-standing research efforts studying spectral quality influences on biological systems. Much of the recent work has focused on the use of LEDs as an alternative lighting source for growing plants or for human habitat lighting applications.
- Initiated the development of a Phase II Small Business Innovation Research with Physical Sciences, Inc., to install a solar light collector and deliver photosynthetically active radiation via fiber-optic cables into a CEC.
- Provide unique low-RH environments for electrostatic testing of materials used for Shuttle, ISS, and Crew Exploration Vehicle applications.
- Support a Center Director's Discretionary Fund project requiring unique $CO_2$ atmospheres (up to 10,000 ppm) to study the altered physiology and metabolite profile of crop plants used for bioregenerative life support.



*Researchers performed charge decay testing of the Kapton purge barrier curtain under ultra-low RH conditions within one of the CECs.*

## *Staff Credentials*

- Plant Physiologist
- Systems Engineer
- Electromechanical Technician V



*Spectral characterization of a six-channel LED array was performed in the CEL. This unique LED array allows for separate control of six different wavelengths of light, providing unlimited light spectral treatments.*

*LPTB chamber*

*Laboratory Operator & POCs:*
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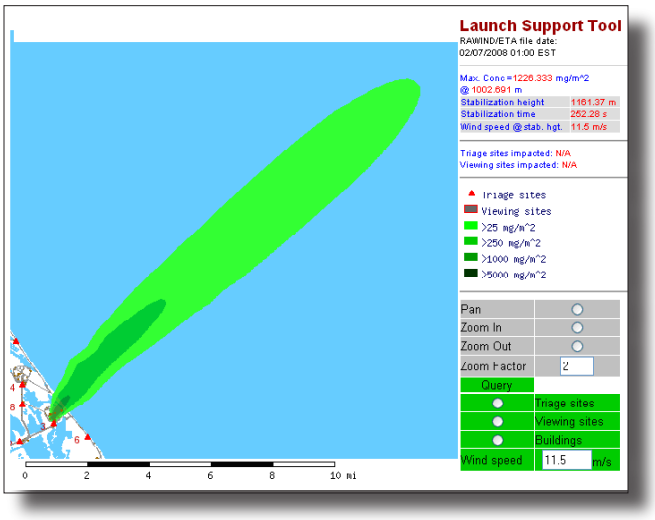
*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Earth Systems Modeling and Data Management Laboratory

The Earth Systems Modeling and Data Management (ESM & DM) Laboratory uses emerging technologies to logically warehouse, analyze, synthesize, and visualize data to interpret ecological processes and advance ecological research and environmental management at Kennedy Space Center. The ESM & DM Laboratory provides expertise in graphical information systems (GIS), image processing, Global Positioning System (GPS), environmental modeling, and the Environmental Database Management System (EDMS), an enterprise Oracle relational database. It maintains nearly a terabyte of environmental data from over 27 years of monitoring and research at KSC on water quality, terrestrial vegetation, sea grass, Florida manatees, sea turtles, scrub jays, wading birds, air quality, and weather. In addition, key Space Transportation System (STS) launch monitoring data is provided to support NASA Safety and Operations. Efforts during the past few years have predominantly addressed the logical warehousing and archiving of several long-term environmental data sets, as well as miscellaneous short-term projects. The ESM & DM Laboratory provide user-friendly tools to access and view data within the EDMS, allowing data export to a customized Graphical Data Screening Tool (GDST) for rapid access, viewing, and analysis.



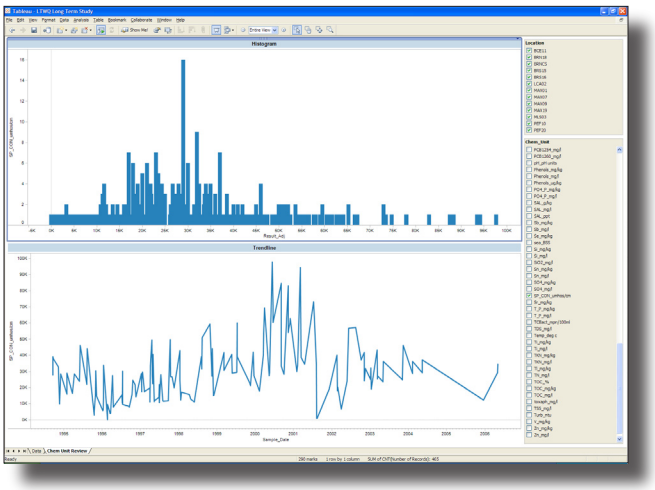

*Simulation modeling*

## Laboratory Services

- Systems administration (Unix Solaris 10.0, Linux Red Hat REL5)
- Database design, administration, and warehousing (Oracle 10.2 Enterprise Server, PostgresSQL 8.0.1, MS Access) and data warehousing support
- Image analysis, GIS development, spatial-temporal analyses, and simulation modeling
- GPS technology
- Web development

## Laboratory Assets & Specialized Equipment

- SUN Microsystems Enterprise 450 and 250 servers
- SUN StoreEdge 3320 disk storage array
- Linux-based PC Web servers
- Richards zoom transfer scope, roll film light table, and stereoscope table
- Aerial, U-2 military aircraft, and satellite imagery spanning over six decades
- Digitizing tablets, slide scanners, slide makers, and large-format plotters



*Visual data exploration and analysis using Tableau*

## Recent Notable Achievements

- Integrated the Environmental Integrated Model (EIM) to accommodate most environmental data associated with the Life Sciences Service Contract (LSSC) and transfered EIM technology to the St. Johns River Water Management District.
- Initially integrated Oracle Spatial component with existing environmental data occurring in the EIM and Environmental Systems Research Institute (ESRI) Spatial Data Engine.
- Coordinated the Mosquito Lagoon prop scar mapping project in 2007 through the integration of a tracking grid to inventory mapping status. Initial analysis of the 2007 data versus reports from the early 1990s showed a decline in the severity of prop scaring.
- Reconstructed a large Oracle database defining KSC baseline water quality, soil, and sediment data collected in the late 1990s.
- Successfully warehoused disparate data sets associated with the EPA Wetlands Initiative.
- Developed user GDST for analysis of long-term water quality chemistry and physical data, long-term lagoonal sea grass, foraging-bird habitat use, water bird nesting colonies, and seasonal habitat usage of the red drum, bluntnose stingray, Atlantic loggerhead sea turtle, and green sea turtle.
- Provided updates to the herbarium listing for KSC and vicinity residing in the EDMS.
- Performed customized programming for ESRI's ArcPAD to aid in surveys of boat usage in Mosquito Lagoon, long-term aerial surveys of manatees in the Banana River and Banana Creek, and beach surveys of disoriented sea turtles.
- Continue to support STS launches from an established Environmental Evaluation Console in the Range Operations Control Center.
- Completed the Canaveral National Seashore Geological Inventory.
- Assist in forming and moderating the Information-Theoretic Working Group, which consists of a group of scientists from the LSSC who meet regularly to collaborate on learning and implementing information-theoretic model selection with multimodel inference as a tool for science-based natural resource monitoring and decision support.
- Implement Web-based GIS using ESRI's ArcIMS and freeware MapServer. Key Web-based projects include Preliminary Environmental Assessment Tool to identify areas for development and provide a list of threatened and endangered flora and fauna, Launch Support Tool to run the Rocket Exhaust Effluent Diffusion Model used during STS launches, animated historical fires at KSC since 1943, and a display of threatened and endangered plant species on and around KSC.
- Continue development of the Coastal Monitoring and Analysis Project to assess coastal change (e.g., erosion) on Merritt Island – Cape Canaveral Barrier Island Complex.
- Incorporate commercial off-the-shelf visual analysis software to assist in the gleaning and synthesis of environmental data (e.g., Tableau).
- Developed the of Automated Utility Data Reporting System, a Web-based reporting system for monthly facility energy consumption.
- Incorporated the Integrated Taxonomic Information System with the EIM.

## Staff Credentials

- Ecologist/Environmental Scientists
- Computer Scientist
- Zoologist
- Data Developer
- Database Administrator

*Laboratory Operator & POCs:*
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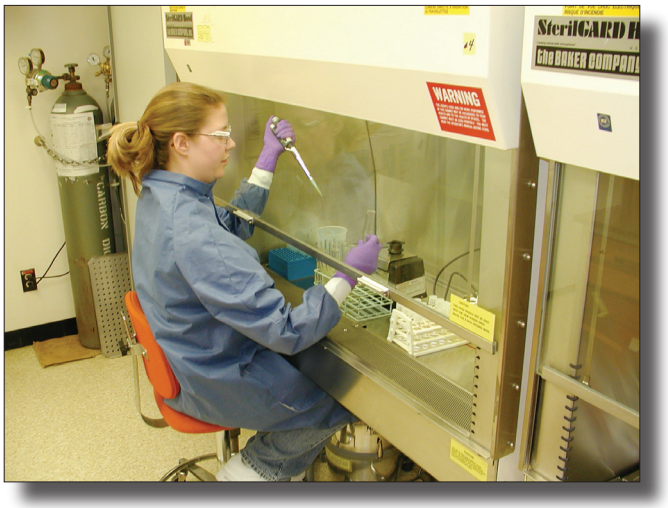
*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Environmental Microbiology Laboratory

The Environmental Microbiology Laboratory is a State of Florida Licensed Water Laboratory certified (under provisions of the National Environmental Laboratory Accreditation Program [NELAP]) to perform bacteriological analyses on drinking and environmental waters. The laboratory supports base operations by testing drinking, environmental, and recreational water samples for KSC, Cape Canaveral Air Force Station, and Patrick Air Force Base. Air and surface microbial sampling, indoor air quality surveys, and *Legionella* and *Giardia* monitoring services are also offered. The laboratory provides microbiological sampling services to the Space Shuttle, International Space Station (ISS), other flight vehicles, and flight hardware. In addition, the laboratory may support principal-investigator-led research projects for life sciences and space flight.




*Biohood*

## Laboratory Services

- Bacteriological testing of drinking and environmental waters
- Bacteriological sampling of air, surfaces, and fluids from flight vehicles, flight hardware, payloads, animals, etc.
- Bacterial and fungal identifications (microscopic, phenotypic, and molecular methods)
- Indoor air quality investigative surveys
- Sterility testing
- Autoclaving and sterilizing services
- Clinical chemistry and microbiology services through the KSC Clinical Laboratory
- Digital imaging and archiving

## Laboratory Assets & Specialized Equipment

- Andersen Air Sampler
- Autoclave (Steam)
- Autoplater 4000
- Biolog MicroStation
- Mattson Garvin Sampler
- Media Plater-Stacker
- Membrane filter manifold
- Polymerase Chain Reaction (PCR) Thermal Cycler
- Q-Count Analyzer
- ScanRDI Analyzer
- Ultrapure Water System
- Zeiss Inverted Microscope

## *Recent Notable Achievements*

- Served as planetary protection-validation laboratory for microbiological burden assays for the Mars Reconnaissance Orbiter (2005) and Mars Exploration Rover Missions (2003).
- Received certification from NELAP and the State of Florida after rigorous examination of the laboratory's procedures, protocols, and records, including operating procedures, quality control manual, personnel training records, and facilities.
- Presented "Utilization of Aminosilane Antimicrobial Coatings in Spacecraft Potable and Technical Water System" paper at the 2007 International Conference on Environmental Systems.
- For presentation at Habitat 2004, conducted research on opportunistic pathogens in the ISS drinking water.

## *Staff Credentials*

- Microbiologist
- Molecular Biologist
- Biologist
- Medical Technologist

*Laboratory Operator & POCs:*
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*David.A.Tipton@nasa.gov, (321) 867-6385*

*Contractor – Dr. Arthur Arnold*
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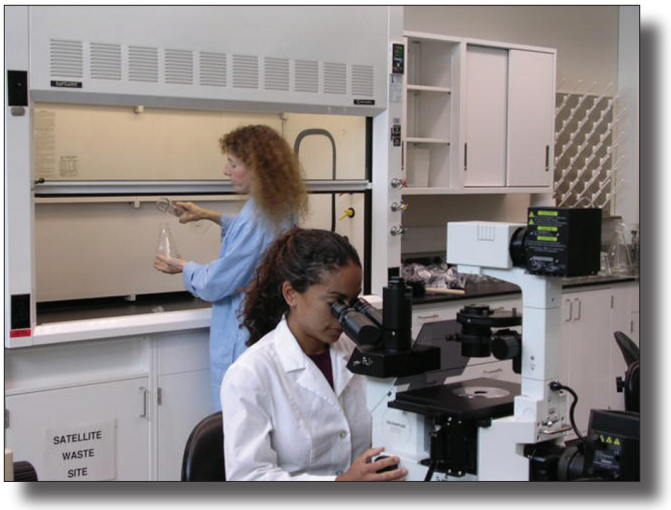
*Arthur.A.Arnold@nasa.gov, (321) 867-2920*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

# Experiment Support Laboratories

The Experiment Support Laboratories are a group of labs that support experimental ground-based studies and testing, ground control activities, flight hardware buildup and development, and postflight activities for experiments returning from orbit, and conduct ongoing resident research in the Space Life Sciences Lab. The labs provide a basis for principal investigators to conduct preflight science activities and science-to-hardware integration in preparation for the installation of payloads into the Space Shuttle. Designed for maximum flexibility, the labs can be configured in various ways to accommodate science experiment disciplines that include cell culture science, plant physiology, and protein crystal growth to name a few. The labs have successfully supported numerous Space Hab, Mars, and SpaceLab missions, and payloads for the Space Shuttle, the Mir Space Station, and the International Space Station. The lab group includes science and hardware integration laboratories, a central services room, shared-equipment rooms, and a walk-in cold room.




*Experiment Support Laboratories preflight operations*

## Recent Notable Achievements

- The Experiment Support Laboratories and associated personnel have repeatedly demonstrated the ability to support the space flight experiments of international space agencies and their researchers, fostering international cooperation between NASA and other space agencies around the world. These have included the European Space Agency (ESA), the Japanese Space Agency (JAXA), the German Space Agency (DLR), the Canadian Space Agency (CSA), and members of the Russian and Ukrainian Space Agencies.

- When feasible and in between space flight missions, the resources of the Experiment Support Laboratories have been used to support NASA-funded ground research efforts, thereby making efficient use of resources between missions.

- In all, the Experiment Support Laboratories have supported more than 240 space flight experiments since 1988.

## Laboratory Services

- Configure, outfit, and close out laboratories; calibrate equipment; and dispose of biohazardous, chemical, and radioactive waste
- Provide specimen and hardware support: receiving, condition verification, preparation, transportation, postflight recovery, and import/export
- Simulate experiments, verify/refine scientific protocols and timelines, and support preparation of ground control experiments
- Provide animal husbandry for specimens and provide/coordinate Biospecimen Sharing Program
- Obtain all necessary approvals (Institutional Review Board – human subjects, Institutional Animal Care and Use Committee – animal subjects)
- Coordinate science and hardware turnover to NASA for Orbiter installation
- Provide training and assistance in aseptic operations
- Monitor laboratory environments
- Provide Ssteam/ethylene oxide sterilization with quality control

## *Laboratory Assets & Specialized Equipment*

- Cold-room environment
- Class 10,000 Positive Pressure Transfer Room (15' × 10') equipped with germicidal ultraviolet lamps
- Class 100K Clean Room environment
- Double distilled-water systems
- Ultrapure (18 MΩ) and deionized water systems
- Fume hoods with air, vacuum, and water available in all science laboratories

## *Staff Credentials*

- Research Support Scientists
- Research Support Technologist
- Research Support Technician
- Animal Technologist

*Laboratory Operator & POCs:*
*NASA – David Cox, Mail Stop: KT-B, KSC, FL 32899*
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*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Flight Experiment Development Laboratory

The Flight Experiment Development Laboratory helps scientists develop their experiments into Space Shuttle and/or International Space Station (ISS) payloads. Its primary areas of responsibility are payload mission management and payload engineering. Payload mission management responsibilities include planning, integration, and operation of the payload, including safety analysis, astronaut training, and in-flight mission monitoring. Payload engineering responsibilities include the design, fabrication, testing, certification, and sustaining engineering of the payload flight hardware. The laboratory has three primary facility resources: the experiments monitoring area (EMA), the Orbiter Environmental Simulator (OES), and the bonded storage area. The EMA provides real-time communication support for flight experiments; the OES mimics space flight temperature, humidity, and carbon dioxide environment; and the bonded storage area is available both pre- and postflight. The Flight Experiment Development Laboratory has successfully developed and integrated more than 40 flight experiments.

## Laboratory Services

- Experiment ground controls (OES)
- Payload communications (EMA provides communication links with launch pads, Launch Control Center, Mission Control Center, and Marshall Space Flight Center)

## Laboratory Assets & Specialized Equipment

- Three environmental control chambers (temperature and relative humidity)
- Two Orbiter environmental simulators
- Large and small vacuum chambers
- Surface-mount-technology soldering station
- Flight-certified weight/center-of-gravity table
- Oscilloscopes, voltage meters, and precision ohm meter


*Experiment monitoring area*

## *Recent Notable Achievements*

- Developed an Solid-State Lighting Module for a direct replacement to the current International Space Station (ISS) fluorescent lighting modules.

- Developed the Advanced Biological Research System (ABRS). The ABRS is a Space Shuttle middeck and ISS EXPRESS Rack compatible system to support space-based biological research. The ABRS is manifested to fly in the spring of 2009.

- Developed a Green Fluorescent Protein Imaging System used to provide remote sensing of transgenic biological samples.

- Developed the FASTRACK ™ space experiment platform. The FASTRACK ™ enables the flight of middeck locker systems on various research aircraft including the Zero-G, NASA Reduced Gravity, and suborbital vehicles.

- Provide sustaining engineering for numerous NASA Life Sciences research flight hardware items, including the KSC Fixation Tube, Gaseous Nitrogen Freezer, and Biological Research in a Canister series.

- Develop Advanced Plant Experiments on Orbit (APEX-Cambium) payload, which will perform studies of higher plants in the space flight environment. Specifically, the goal for this payload is to help us understand physiological processes (such as gene expression, metabolism, and general plant development) that are affected in plant systems exposed to microgravity. The payload is scheduled to be flown to the ISS and be installed in the EXPRESS Rack in March 2009.

- Provide mission integration support for numerous customers flying the KSC Fixation Tube (KFT) flight hardware. The KFT allows for chemical fixation on orbit while providing three levels of containment for the hazardous chemicals.

*Orbiter Environmental Simulator*

## *Staff Credentials*

- Biomedical Engineer
- Chemical Engineer
- Communications Engineers
- Electrical Engineer
- Laboratory Technicians
- Mechanical Engineer
- Quality Engineer

*Laboratory Operator & POCs:*
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*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Human Physiology Core Laboratories

The new Human Physiology Core Laboratories consist of the Baseline Data Collection Facility (BDCF) and the Postflight Science Support Facility (PSSF). The facilities are used to support postflight human life science assessment and analyses at the Primary Landing Site in Florida and the Secondary Landing Site at Dryden Flight Research Center, Edwards Air Force Base, California. The Human Physiology Core Laboratories provide a highly integrated, yet flexible, infrastructure that includes customized research laboratories and expert personnel to optimize human life sciences research. The BDCF and the PSSF are the only two facilities in the United States capable of studying astronaut response to space flight immediately upon their return to Earth.

The BDCF and PSSF complexes house experiment-unique hardware items that are used to perform physiological testing on Space Shuttle crew members before, during (monitoring and/or ground controls), and after flight. Past research has included cardiac, venous, pulmonary, musculoskeletal, vestibular, immune, metabolic, circadian, and psychological functions. Research scientists provide general laboratory management and liaison service for researchers. The labs support all medical operations and experiment testing associated with preflight and postflight mission activities at KSC and Dryden.

The facility scientist has primary responsibility for the calibration, installation, and operation of specialized equipment such as magnetic resonance imaging (MRI) assemblies, densitometers, cardiovascular and pulmonary devices, and vestibular testing equipment (rotating chair devices, treadmills, head-and-gaze systems, obstacle courses, etc.). BDCF and PSSF personnel review, assess, coordinate, schedule, and evaluate experiment protocols, validate the integrity of research methods and relevant device systems, and allocate resources, as required. BDCF and PSSF provide a research infrastructure and a technical workforce to support human research and testing in response to space flight and the conditions of a microgravity environment, with potential research applications for the general population.

## Laboratory Services

- Specialized and certified personnel (medical personnel, scientists, engineers, and technicians)
- Microscopy (transmitted-light, brightfield, darkfield, differential interference contrast [DIC], phase contrast and epi-fluoresence)
- Environmental microbiology testing (state-certified by National Environmental Laboratory Conference [NLAC] and Clinical Laboratory Testing [accredited by College of American Pathologists])
- Indoor air quality investigative surveys
- Assistance with technical, safety, and/or local policies, procedures, and regulations
- Assistance with securing equipment, resources, and/or services that are not available at KSC and Dryden

## Recent Notable Achievements

- Completed the hardware installation of the new Ambiguous Tilt and Translation Motion Cues After Spaceflight/Z-Aligned Gravitoinertial (ZAG) and the Otolith Assessment During Postflight Re-Adaptation (Otolith) experiments at the BDCF. The first use of this experiment hardware is scheduled for STS-123 (1J/A). The purpose of the Ekida Rotator is to test the function of the sensory organs in the inner ear (specifically, the otoliths) by providing combined centripetal and

*Posture-MR402 experiment*


*ZAG-Otolith experiments with subject*

translational linear acceleration during constant velocity eccentric rotation. Since the subject is rotating at a constant speed, over time the output from the angular rate sensors in the inner ear (semicircular canals) decays so that the subject perceives no motion. The eccentric rotation paradigm thus provides otolith and other graviceptor cues regarding tilt orientation without concordant canal cues.

- Coordinated, planned, and assisted in collecting data from participating astronauts before and after flight. This includes domestic and international Shuttle and International Space Station crew members following the conclusion of short- and long-duration missions. The data is being used to design and develop countermeasures and effective training methods to hasten the recovery of balance and coordination upon return to a gravity environment.
- Recent astronaut testing activities at the labs include:
  - Cardiovascular Control on Return from International Space Station
  - Spaceflight-Induced Reactivation of Latent Epstein-Barr Virus
  - Job Stocking Tilt Test
  - Lower Body Negative Pressure
  - Crew Surgeon Clinical Assessment
  - Neurovestibular Platform Test
  - Resting ECG
  - Clinical Laboratory Testing
  - Orthostatic Tolerance Active Postural Stand Test
  - Nutritional Assessment
  - Operational Tilt Test
  - Physical Examinations
  - Astronaut Strength, Conditioning and Rehabilitation
  - Sleep-Wake Actigraphy and Light Exposure During Spaceflight
  - SDBI-1900/Integrated Immune (Validation of Procedures for Monitoring Crewmember Immune)
  - ESA-Chromosome-2
  - Vestibular Adaptation to G-Transitions: Motion Perception
  - Ambiguous Tilt and Translation Motion Cues After Spaceflight
- Provided programmatic and operational support for ISS, Spacelab, Shuttle, and Shuttle-Mir missions since 1983.

## *Staff Credentials*

- Biomedical Engineers
- Biomedical Technicians
- Facility Engineers
- Registered Nurses
- Mechanical Engineers
- Mechanical Technicians
- Physicians

## *Laboratory Assets & Specialized Equipment*

- Microscope systems (upright and inverted frame types; compound, dissection, stereoscopes)
- Centrifuges (tabletop/microcentrifuges, hematocrit, high-speed and cooling centrifuges)
- Laminar flowbenches and biological safety cabinets (Type II, horizontal laminar flow)
- Electrocardiogram (ECG) / EKG units (portable), defibrillators (Lifepak 12), Finapres devices, gurneys, wheelchairs, and other general medical devices
- Refrigerators and freezers for controlled specimen and reagent storage (+4 ˚C, –20 ˚C, –70 ˚C)
- Flammable materials and radioisotope storage
- $CO_2$ water-jacketed incubators, waterbaths, thermal array recorders, pH meters, vortex mixers
- 18 MΩ distilled water and double-distilled water systems
- Access to the Crew Transportation Vehicle for experiment setup and testing purposes
- Mission Elapsed Time (MET) / Greenwich Mean Time (GMT) Countdown Clock Systems

*BDCF Laboratory Operator & POCs*
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*Contractors – Mimi Shao, Mail Stop: BDCF, KSC, FL 32899*
*Yai-Ping.M.Shao@nasa.gov, (321) 867-7175 / 867-8878*

*Location:*
*Operations and Checkout Bldg. (M7-355)*

*PSSF Laboratory Operator & POCs*
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*LSSC – Bill McLamb, Mail Stop: DYN-3, KSC, FL 32899*
*or during mission at DFRC,*
*Attn: Bill McLamb, P.O. Box 273, MS 4845A, Edwards, CA 93523-0273*
*William.T.Mclamb@nasa.gov, (661) 276-2605*

*Location:*
*Postflight Science Support Facility*
*Dryden Flight Research Center (Bldg. 4822)*

# Light Testbed

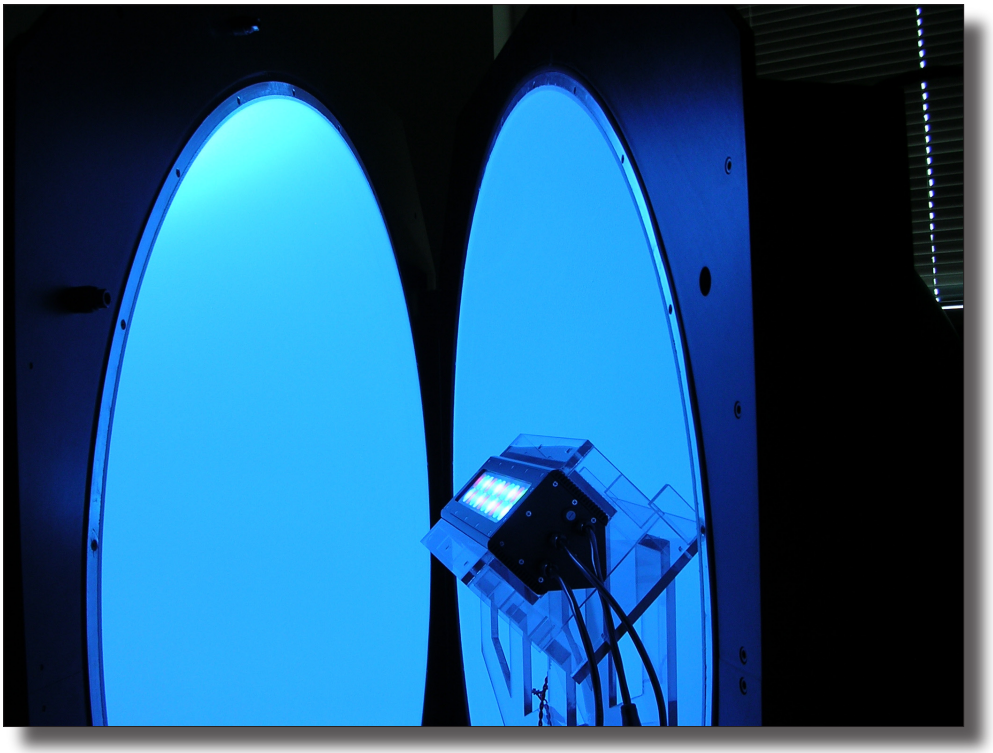
The Light Testbed is a fully functional photometric test lab capable of meeting all of our clients' light measurement needs. Light Testbed capabilities include total photopic luminous flux, total scotopic luminous flux, color rendering index (CRI), correlated color temperature (CCT), radiant efficiency, luminous efficacy, and color coordinates in Tristimulus, CIE 1931, CIE 1960, and CIE 1976 color spaces. Plant responses capabilities include determining total photosynthetic active radiation (PAR), photosynthetic photon flux (PPF), and phytochrome photostationary state. Intensity distribution profiles are also determined using our two-axis goniometer. Light-emitting diode (LED)-specific characterization includes dominate wavelength, purity, and full-width half-max (FWHM), as well as full intensity distribution using our LED goniometer.

## Recent Notable Achievements

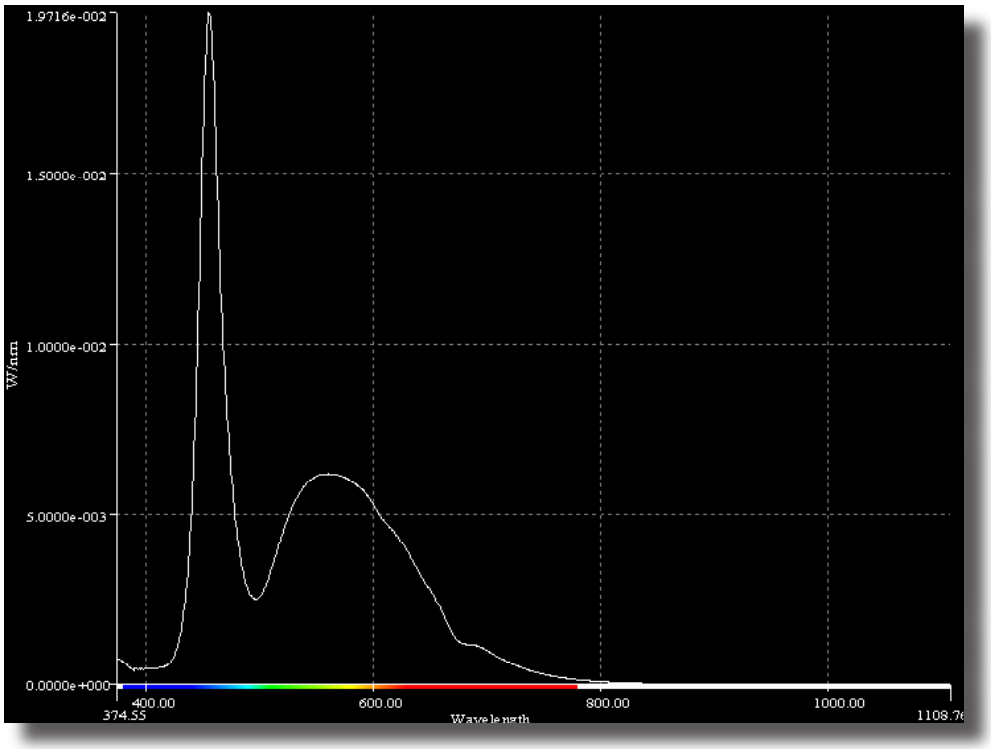
- Solid State Lighting Module analysis
- Commercial off-the-shelf (COTS) LED luminaire analysis

## Laboratory Services

- Spectroradiometric analysis of any luminaire, including CCT, color coordinates, CRI, and power spectrum distribution
- Measurment of total photopic and scotopic luminous output of any luminaire 1 m or less in maximum dimension
- Complete LED analysis, including CCT, CRI, and intensity distribution profiles
- LED characteristics such as CRI, CCT, and intensity with respect to angle
- Full photometric data report generation for luminaires with maximum diameter less than 30 centimeters
- Near-field photometric data report generation for luminaires with maximum diameter greater than 30 centimeters
- Controlled environment laboratory setup for lighting analysis of different environment conditions



*Inside of 1 m integrating sphere with custom lamp hold to ensure lamp center is in the same position as the calibration lamp for accurate measurements.*




*Sample spectral power distribution measured by spectroradiometer. Test lamp was placed in the 1 m integrating sphere for this measurement.*

## *Laboratory Assets & Specialized Equipment*

### *Integrated Spheres:*

- 0.15 m, 0.5 m, and 1 m. Custom test stands are built for each luminaire.
- Spectroradiometer measuring wavelengths in the visible and near-infrared spectra.
- Two-axis goniometer with 180º primary axis rotation and 360º secondary axis rotation.
- Two-axis LED goniometer with 180º primary axis rotation and 360º secondary axis rotation.
- One 4.46 m² black room adapted controlled environment chamber.

## *Staff Credentials*

- Biomedical Engineer
- Chemical Engineers
- Communications Engineer
- Electrical Engineer
- Mechanical Engineer
- Quality Engineer
- Laboratory Technician

*Laboratory Operators & POCs*
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*Dr. Gary Stutte, Mail Code DYN-3, KSC, FL 32899*
*Gary.W.Stutte@nasa.gov, (321) 861-3493*

*Location:*
*Space Life Sciences Laboratory (Bldg. M6-1025)*

# Animal Care Facility

The Animal Care Facility provides services that support animal payloads (for preflight, in-flight, and postflight activities and flight simulations) and primary cell culture payloads associated with both the Space Shuttle and the International Space Station programs. It provides facility space, animal care and husbandry, and customer support in conjunction with animal experiments. Functional support and housing areas include animal holding rooms, quarantine, clean- and dirty-side cage wash rooms, surgical suite, and integration/postflight housing room. This Class 100,000 clean room barrier facility is designed to house rodent species. Aquatic species can be supported at the Space Life Sciences Lab in one experiment support laboratory equipped with a floor drain and a poured-epoxy-sealed floor. The Animal Care Program complies with all government standards for animal care, is accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International, is registered with the United States Department of Agriculture Animal and Plant Health Inspection Service, and maintains a current Animal Welfare Assurance approved by the Office of Laboratory Animal Welfare.

## Laboratory Services

- Specific pathogen-free animal housing and husbandry services for rodents and aquatics

*Aquatic Facility husbandry support*

*Preparation of supplies in support of the Animal Care Facility*

## Recent Notable Achievements

- Successful support of SpaceLab and Middeck flight payloads since 1984.

## Staff Credentials

- Electrical Engineer
- Supporting Engineers
- Expert Craftsmen
- Supporting Technicians

*Laboratory Operator & POC:*
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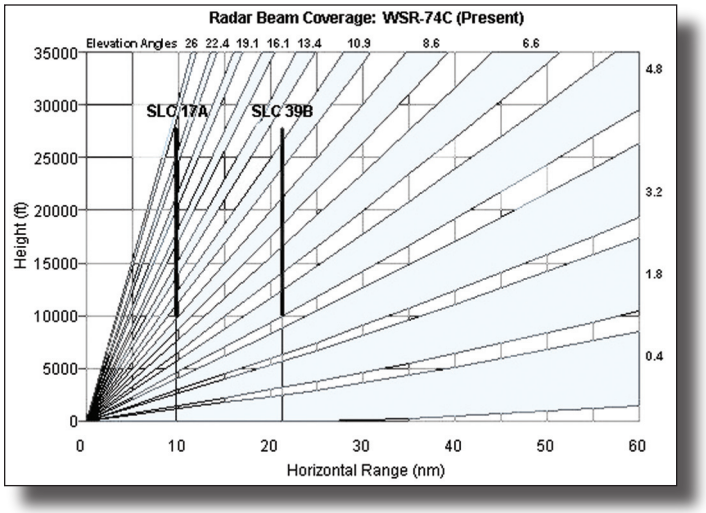
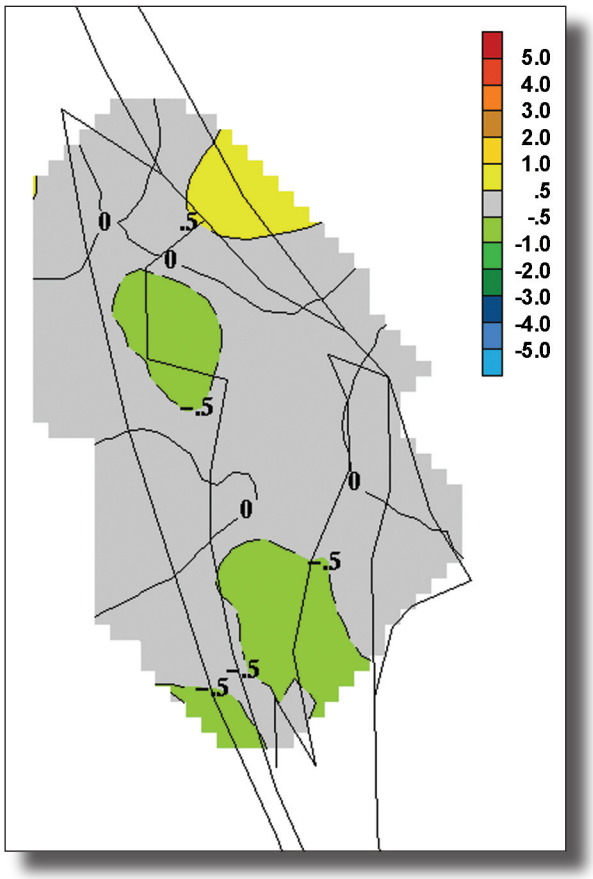
# *Meteorology*

# Applied Meteorology Unit

The Applied Meteorology Unit (AMU) develops, evaluates, tailors, and transitions technology to improve weather support to spaceport and range operations. It is operated under a joint NASA – Air Force – National Weather Service Memorandum of Understanding. Relevant technologies include meteorological instrumentation; atmospheric data analysis; weather forecasting algorithms and indices; and numerical weather prediction, data assimilation, and modeling. The AMU personnel encompass a broad range of expertise, including computational fluid dynamics, computer programming, data analysis and statistics, instrumentation, and weather support to spaceport and range operations.




*Improved scan strategy for the Eastern Range WSR-74C weather radar*

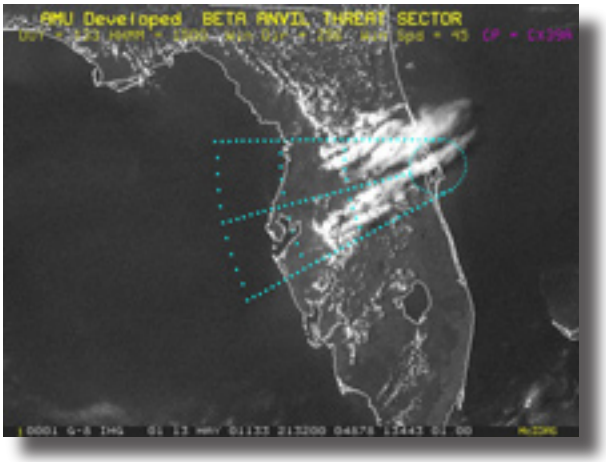



*A new objective technique for quantitatively evaluating the performance of numerical forecast models*

## Laboratory Services

- Development of weather forecasting algorithms, indices, and tools
- Evaluation of meteorological instrument performance
- Evaluation, custom-tailoring, and operational transition of numerical weather prediction systems
- Development of concepts of operation for optimal application of instruments, tools, and models
- Development of training tools and materials for weather sensors, models, and data systems
- Development of data analysis techniques, databases, and data visualization methodologies
- Expert advice on the acquisition and deployment of meteorological instrumentation and modeling systems
- Expert advice on transitioning newly developed or acquired products into operation

*Boundry layer wind profiler using AMU automated quality control algorithm*




*Thunderstorm anvil forecast tool for estimating likelihood of violation of lightning launch commit criteria*

## Recent Notable Achievements

- Developed and installed a method to determine the threat of violating the thunderstorm anvil rule in the lightning launch commit criteria that governs all vehicles launched from the Eastern Range.
- Developed an automated objective algorithm for identifying sea breeze fronts in gridded numerical weather forecasts and observed data. Previous automated processes were unreliable, necessitating a labor-intensive, subjective, manual review before the data could be used.
- Developed an automated method to use the sea breeze identification algorithm to evaluate the performance of the numerical forecasts against the actual observations. Classical point-verification statistics cannot capture phenomenological success or failure in a high-resolution model prediction. The new method accounts for timing and location displacements that cripple the classical methods.
- Developed a fully automated quality control algorithm for radar wind profiler data and used it to assess the performance of the Eastern Range's network of five 915 MHz boundary layer profilers.
- Developed an improved scan strategy for the Eastern Range WSR-74C weather radar. The new strategy eliminated overlap that was present in the previous scan pattern. This resulted in increased coverage (smaller scan gaps) without increasing the time necessary to complete a scan.

## Laboratory Assets & Specialized Equipment

- Advanced Weather Interactive Processing System (AWIPS)
- Meteorological Interactive Data Display System (MIDDS)
- 16-node 32-processor high-performance Linux cluster

## Staff Credentials

- Atmospheric Scientists
- Meteorologists

*Laboratory Operator & POCs:*
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As the CTC Program Manager, I would like to thank you for your interest in the exciting capabilities that KSC has to offer. KSC's world-class workforce offers innovative and efficient solutions to meet your needs. The laboratories and services listed in this book are available to you to assist in making your vision a reality.

Please feel free to contact me or any of the laboratory managers with questions.

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| Core Technical Capability | NASA POC | Contractor POC |
|---|---|---|
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| Nondestructive Evaluation Laboratory | | Kenneth Walla<br>Kenneth.C.Walla@nasa.gov<br>(321) 861-0620 |
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| Polymer Science and Technology Laboratory | Dr. Martha K. Williams<br>Martha.K.Williams@nasa.gov<br>(321) 867-4554 | |
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